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NOTICES

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VEGETATION AND PEAT OF A SMALL MIRE AT PLIMMERTON, NORTH ISLAND, NEW ZEALAND

By N. T. MOAR, Botany Division, Department of Scientific and Industrial Research, Wellington

(*Received for publication, 8 January 1953*)

Summary

Peat in a valley lying a little above sea-level at Plimmerton, New Zealand, has evidently formed under a high water-table; the deepest peats are only slightly above mean sea-level. Sedge peat generally overlies clay and sand, but shingle is found beneath the shallow peat at the "barrier" which separated the present valley from the sea. Plant fragments were found both in the peat and in the upper layers of clay, and fruits of *Ruppia spiralis* L. and fragments of a bivalve mollusc occurred in sand underlying peat at one place. The peat at Plimmerton is compared briefly with the woody Paraparaumu peat, and is considered to be potentially fertile and of a type suitable for cultivation.

INTRODUCTION

In August, 1950, an area of reclaimed peat at Plimmerton, near Wellington, was investigated at the request of the Regional Planning Council. Numerous borings were made to determine the depth of the peat and the nature of the underlying strata. The purpose of this paper is to consider the nature and formation of peat in this area as a contribution to the botanical classification and utilization of the wide range of peat deposits in New Zealand.

About 210 acres of peat have accumulated in a shallow valley extending over one and three quarter miles in a north-east direction from Plimmerton railway station. According to Adkin (1921) this mire has been formed as a result of marine transgression and subsequent separation of the inlet from the sea by a shingle beach 7 ft high, which impounded a lagoon and effectively blocked drainage. Adkin (loc. cit.) also refers to an uplift of 3 ft in the Porirua Harbour area at the time of the 1855 earthquake.

The lower part of the valley is about three quarters of a mile wide, but suddenly becomes much narrower at and above the tile works (Fig. 1). The peat was investigated in the lower broader part where it has been reclaimed for farming. A vegetation survey included the less altered narrow part of the valley, which in 1947 was cut over for

Phormium fibre. As a result of draining, burning and grazing over a long period, the peat in the lower part has shrunk and consolidated. The surface is only slightly hummocky, but severe fires at the southern end have resulted in an extensive shallow depression which rapidly becomes water-logged after rain. Peat has been disturbed by the formation of the main highway from Wellington which bisects the widest part of the valley. The main trunk railway line skirts the western side and embankments have separated small areas from the main mire.

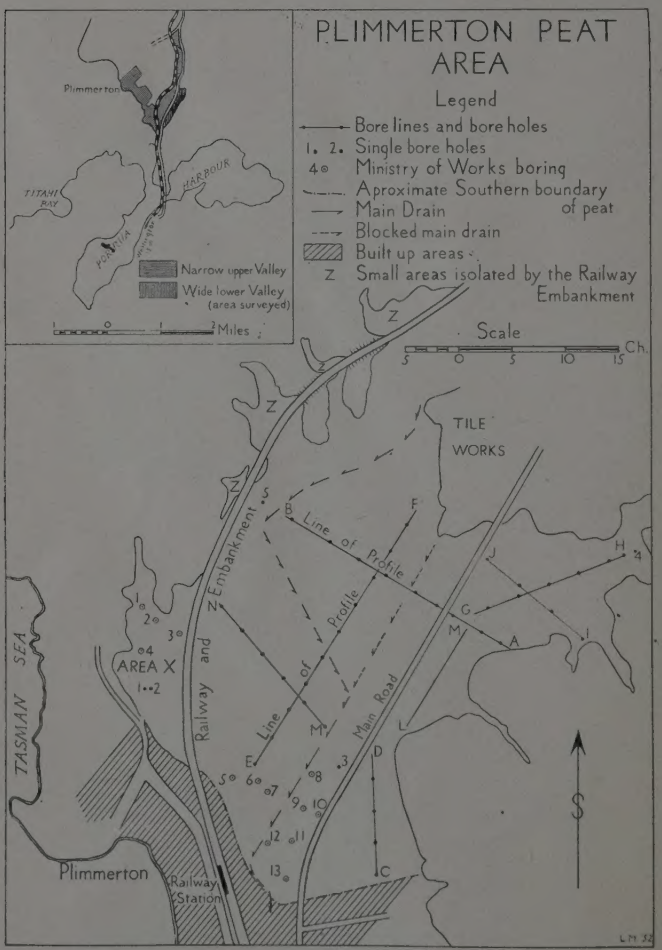

FIG. 1.—The Plimmerton peat area investigated. Inset is the locality map with the extent of the valley indicated.

The peat is generally less than six feet deep, but depths of more than nine feet were twice recorded. The deepest peat of the profile (Fig. 2) was about three feet above mean sea level.

VEGETATION

The plant cover of the upper unreclaimed part has developed with the water-table slightly above the peat surface. Several vegetation units in this part can be distinguished physiognomically.

The upper half of the narrow valley is dominated by *Phormium tenax* Forst., through which spindly shrubs of *Hebe salicifolia* (Forst. f.) Pennell and *Coprosma robusta* E. Raoul occasionally appear. *Carex secta* Boot., on the trunks of which *Blechnum procerum* (Forst. f.) Labill. is common, forms an almost impenetrable growth four to five feet high. Other species present include *Arundo richardi* Endl., *Typha muelleri* Rhorb., *Eleocharis acuta* R.Br. and *Epilobium pallidiflorum* Sol. ex A. Cunn.

An extensive area dominated by *Typha muelleri* is clearly separated from the *Phormium-Carex* area described above. *P. tenax, A. richardi, Carex virgata* Sol. ex Hook. and *Eleocharis acuta* are present and vary in density from point to point.

An area of several square yards close to the road embankment near the tile works is dominated by *Leptocarpus simplex* A. Rich. Accompanying species include stunted *Leptospermum scoparium* Forst., *P. tenax, Euphrasia cuneata* Forst. f., *Epilobium pallidiflorum, Drosera binata* Labill., *Centella uniflora* (Col.) Nannfeldt, *Blechnum procerum* and *Cladium glomeratum* R.Br. The last named species increased in dominance around the wetter margin.

Less well defined areas occur below these clear cut zones in which *P. tenax, A. richardi, C. secta* and *T. muelleri* are of about equal importance. *Carex ternaria* Forst. f. is dominant in a strip separating the unreclaimed from the reclaimed parts.

In the reclaimed area there is now little evidence of the original plant cover. Three rather ill-defined units can, however, be recognised.

On the eastern side of the main highway there is a dense growth of the rush *Juncus polyanthemos* Buchen., with *C. ternaria, Mariscus ustulatus* C. B. Clarke and *Dactylis glomerata* L. scattered throughout. There is a gradual change to pasture, which occasionally forms a dense turf, but is generally open with scattered *J. polyanthemos* and *J. effusus* L., *Holcus lanatus* L., *Lolium perenne* L., and *Rumex acetosella* L. are major constituents of the turf.

In the depressed zone at the southern end, *C. secta* and *J. polyanthemos* form a dense cover with some *C. virgata, M. ustulatus, D. glomerata* and, in the wetter parts, *Agrostis stolonifera* L.

In choked drains south of the tile works *C. secta* and *T. muelleri* are established and in the more open drains *Potamogeton cheesemanii* A. Benn. is present. Several plants of *Phormium tenax* are scattered over the peat just south of the tile works.

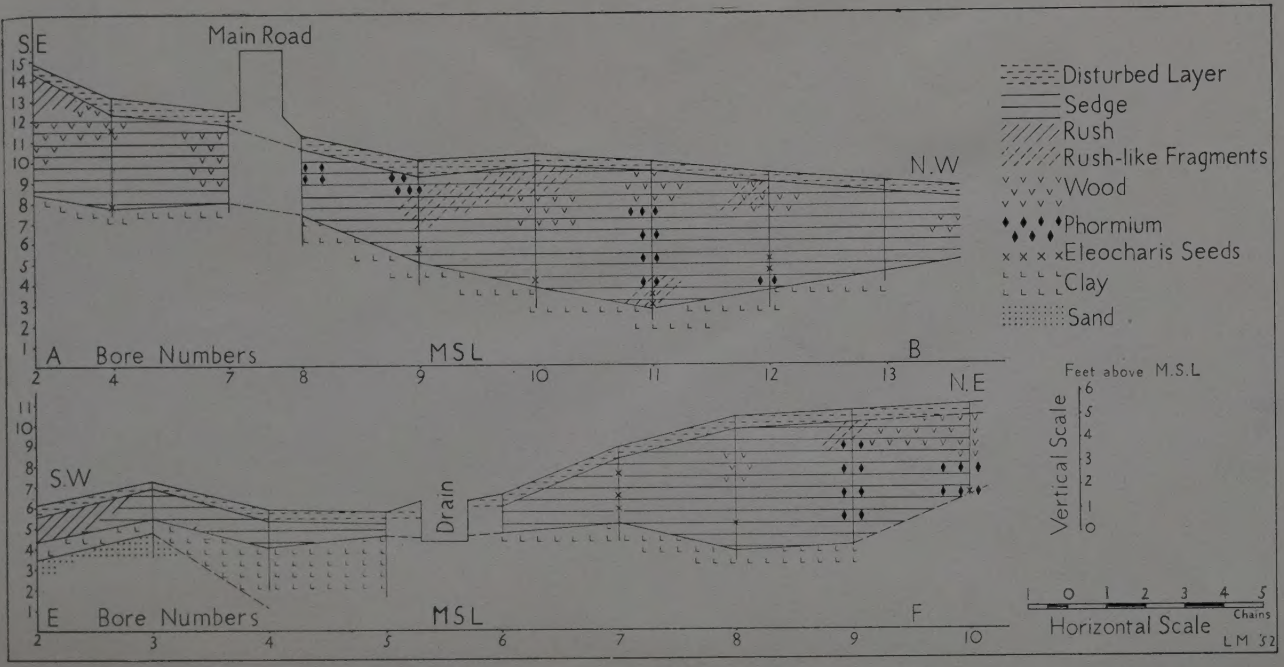

FIG. 2.—Peat profiles A—B and E—F. The height of the peat above Mean Sea-Level is indicated.

THE PEAT AND UNDERLYING STRATA

After a preliminary survey of the area and with the aid of an aerial photograph supplied by the Ministry of Works, it was decided to work seven bore-lines (Fig. 1). Borings were made along each line at three-chain intervals and additional borings were made as checks at different points away from the lines. Details of four borings made in Area X and of nine at the southern end on the western side of the main highway were made available by the Ministry of Works. In order that the depth of peat in relation to mean sea level and the topography of the underlying strata could be shown, levels were taken at each bore-hole along lines A–B and E–F by Ministry of Works surveyors.

(a) *Depth*

The deepest peat was found along Bore-line G–H where depths of 7 ft 5 in., 7 ft 6 in. and 9 ft 2 in. were recorded for Boreholes 1, 2 and 3 respectively; a sudden increase in depth from 2 ft 1 in. to 9 ft 2 in. was recorded on Line I–J. Depths of more than six feet were recorded at borings on Lines A–B and E–F. A uniform depth of 6 ft was recorded by the Ministry of Works in Area X.

As was expected, the peat became shallower towards the southern end and was absent at the shingle "barrier" and near the school buildings on the eastern side of the road (Fig. 1). Ministry of Works borings made near the "barrier" showed a shallow layer of peat 12 in. deep and at about 10 ch. (Point 8) from these the depth had increased to 24 in. Along Line C–D depths increased regularly from 0 to 19 in.

(b) *Deposits Underlying Peat*

Near the "barrier", the peat overlies shingle resting on sand. Elsewhere it overlies a layer of clay which varies in thickness and which rests on sand. Under the deepest peats, the clay layer was thick and was only occasionally penetrated by the auger. At Bore-hole 11, Line A–B, clay was more than six feet thick and although the transition from clay to sand was not recorded, sand with shell fragments was found at a depth of twenty feet below the peat surface. At the Ministry of Works borings on Area X, peat similarly overlies clay or sandy-clay, but it was only at Bore 4 that the clay, 11 ft thick, was penetrated to the underlying shelly sand. Clay a least 9 to 12 ft thick found in Bores 1, 2 and 3 was not penetrated. The following profile of an independent boring made near the edge of this area shows a similar sequence, except that a layer of sand was immediately below the peat.

Depth of Layer (in.)	Composition of Layer
0 — 40	peat
40 — 66	sand
66 — 89	clay
89 +	sand with shell fragments

Identifiable fragments of a bivalve mollusc *Chione stutchburyi* Gray, and three fruits of *Ruppia spiralis* L. were isolated from the sand at 89 in. +.

Plant fragments and seeds were also found in the top layers of clay, and in transition layers between peat and clay, at many of the bore-holes.

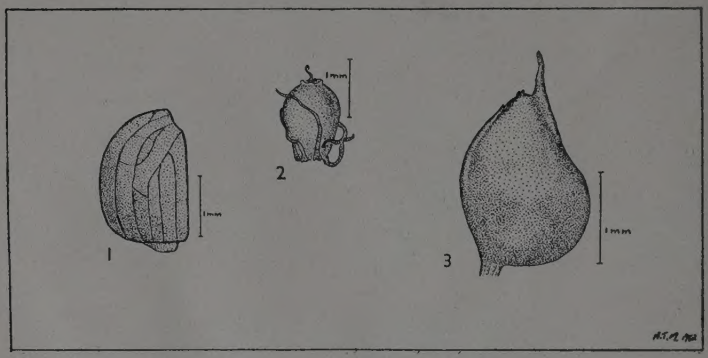

FIG. 3.—Fruits and nuts isolated from peat and sand. 1. *Centella uniflora* (peat); 2. *Eleocharis sp.* (peat); 3. *Ruppia spiralis* (sand, Area X).

(c) *Peat Profiles*:

The peat is predominantly "sedge"*, with wood, rush and some moss fragments in the upper layers. Fragments of *Phormium* leaves, *Phormium* fibres and rootlets, and nuts of *Eleocharis* sp., were frequent at all depths. Two fragments of fruit of *Centella uniflora* were also isolated at a depth of 20 in. (Fig. 3).

The uniform nature of the peat is shown by two profiles (Fig. 2), which may be considered typical of the whole area, although identifiable fragments were sometimes more frequent in other bore-holes.

Bore-hole 9, Line A–B, is typical of the many profiles examined.

Depth of Layer (in.)	Composition of Layer
0 — 14	brown, fibrous with ash present, disturbed layer
14 — 21	black, *Phormium* fibres present
21 — 35	reddish brown, some rush fragments
35 — 56	reddish brown, very fibrous with nuts of *Eleocharis* sp. in top layer
56 — 60	transition from above to
60 +	blue-grey clay

A comparison with Bore-hole 3, Line G–H, below shows the general similarity of the peat.

Depth of Layer (in.)	Composition of Layer
0 — 22	peaty loam, disturbed layer
22 — 29	dark-brown, very fibrous
29 — 36	grey-brown, peaty loam
36 — 57	brown, *Phormium* fibres present
57 — 67	dark-brown, wood and fern fragments present
67 — 77	red-brown, very fibrous
77 — 107	light-brown, *Phormium* leaf fragments and fibres, some wood remains at bottom
107 — 110	transition from above to
110 +	blue-grey clay with some wood fragments

Some evidence of flooding from the surrounding hills was found along Line G–H only. At Bore-hole 4, at a depth of 30 in. a blue-grey mud, 6 in. deep, was overlying "sedge" peat in which *Phormium* root-

* The classification proposed by Harris & Filmer (1946) and later amended by Harris (in press) is used in this paper.

lets and fibres, and nuts of *Eleocharis* sp. were plentiful. At the same depth at Bore-hole 5, a layer of blue-grey clay 6 in. deep was present. Except for this narrow band of clay the profile described below was similar to the rest.

Depth of Layer (in.)	Composition of Layer
0 — 7	brown disturbed layer
7 — 14	dark-brown peaty loam
14 — 22	dark-brown; very fibrous; some wood fragments
22 — 29	dark-brown; loamy; some rush fragments
29 — 30	transition to
30 — 36	blue-grey clay
36 — 50	dark-brown peaty loam
50 — 59	dark-brown; *Phormium* rootlets present
59 — 67	grey-brown with wood fragments
67 — 77	silty mud with wood fragments
110 +	blue clay

Rush-like fragments were recorded from various depths in many profiles, but the only rush peat found was at the eastern margin of Line A–B. Plant material in this peat was not identified beyond this broad category.

Wood fragments, which were generally more frequent in the upper layers of peat, were too much decomposed for identification.

In all profiles the surface layers of peat have been affected by burning. This is particularly well shown along Line M–N, and may be illustrated in the following profile of Bore-hole 1.

Depth of Layer (in.)	Composition of Layer
0 — 22	red-ash; deeply burnt
22 — 36	red-brown; fibrous
36 — 43	blue-grey silty clay

DISCUSSION

An examination of the profiles (Fig. 2) shows that in these the deepest peat is about three feet above mean sea level. If the Porirua Harbour area was raised as a result of the 1855 earthquake (Adkin, 1921), the deepest peats must have accumulated not much above mean sea level.

The presence of *Phormium* remains and nuts of *Eleocharis* sp. at the transition between peat and the underlying clay suggests that peat formation began under a high water-table, and similar remains found at various depths in the profiles show that conditions of accumulation have been constant. The "sedge" peat in this area could have been formed from vegetation similar to the *Phormium-Carex* dominant areas found today in the upper part of the narrow unreclaimed valley. Wood fragments are interpreted as being the remains of shrubs such as *Hebe salicifolia* and *Coprosma robusta,* as in general such remains were found in "sedge" peat.

The constituents of the "rush" peat may represent a narrow belt of *Cladium glomeratum* and possibly *Leptocarpus simplex* as described.

The record of three fruits of *Ruppia spiralis* and fragments of *Chione stutchburyi* from one boring in Area X adds some support to the explanation of marine transgression put forward by Adkin (1921). According to Miss R. Mason *Ruppia spiralis* grows as well in fresh water as in brackish water, and *Ruppia* fruits produced by plants growing in brackish water in New Zealand can be distinguished by their greater size from the fruits of fresh water plants. The fruits from Area X are typical of brackish water plants, (pers. comm.). Powell (1947) states that *Chione stutchburyi* lives "just beneath the surface in muddy localities from mid-tide to low-tide." These facts, and records of shell fragments in other parts of the area are evidence of marine transgression.

A comparison of this mire with that at Paraparaumu (Moar, 1952) is useful. Although both are coastal and have been initiated by the formation of a topographic barrier, their development has differed considerably. At Plimmerton the peat is predominantly "sedge," whereas the Paraparaumu peat is mainly woody, overlying a shallow "rush" or "sedge" peat. These differences are shown in a striking manner by the density of stumps at Paraparaumu and by their absence at Plimmerton. The cratered, pitted appearance of burnt peat at Paraparaumu is distinct from the evenly burnt surface of the Plimmerton mire.

The uniform nature of the peat and the absence of wood in it add to the value of the Plimmerton area. A "sedge" peat as at Plimmerton may be regarded as fertile. This fertility is indicated by the vigorous growth of scattered plants of *Phormium tenax* on the reclaimed area.

ACKNOWLEDGMENTS

The author wishes to acknowledge his thanks to Miss R. Mason for identifying seeds and to Dr. J. Marwick who identified shell fragments.

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SOIL DISINFECTION

XIV. EFFECT OF CHEMICAL SOIL DISINFECTANTS ON CONTROL OF WEEDS

By H. Jacks, Plant Diseases Division, Department of Scientific and Industrial Research, Auckland

(Received for publication, 4 December 1952)

Summary

The effect on weed control of chloropicrin, D-D, Formalin, Iscobrome II, carbon disulphide, and mixtures of chloropicrin and D-D, and chloropicrin and Isobrome II was investigated.

Chloropicrin was more effective than other materials. Although both chloropicrin and D-D, in general, considerably reduced emergence of wood weed seeds, neither gave satisfactory control of clover and grass seeds.

Introduction

It is desirable that soil disinfection carried out for control of diseases and pests should also inhibit germination of weed seeds. The value of soil steaming for control of soil-borne organisms and weed seeds is well known. As chemical methods for soil disinfection are now widely used, experiments were carried out to test the effect of such treatments on weed conrol.

Experimental Methods and Results

Materials and methods of application of soil disinfectants to nursery and glasshouse soil have been described (Jacks, 1945 a and b, 1946). Further details of methods used in the present experiments are given below. Emergence of weeds was recorded 60 days after soil treatment in all experiments.

I. *Susceptibility of a Range of Weeds to Soil Fumigation*

A. *Treatment of Small Amounts of Soil*: For purposes of ascertaining which species of weeds were controlled by soil fumigation a wide range of weed seeds was collected, dried and divided into lots of 100. Emergence rate of each species was assessed from 500 seeds sown in steam disinfected soil maintained at 40 per cent water holding capacity. Seeds of poor germination were not included in tests.

One hundred seeds of each species were mixed with 20 cu. in. of steam-disinfected soil (volcanic loam) and placed in quart jars with screw type lids, five replications being used for each species and treatment. Chloropicrin and D-D were applied at rates of 12, 6 and 3 ml. per cu. ft., i.e. 0.14, 0.07 and 0.035 ml. per container, and carbon disulphide at rates of 36, 18 and 9 ml. per cu. ft., i.e. 0.42, 0.21 and 0.11 ml. per container. Soil was removed 48 hours later and spread over the surface of steam-disinfected soil in 8-in. pots. Controls (steamed soil) were included with each set of treatments for each weed species. Pots were placed in a glasshouse. Survival of weed seeds recorded in treatments is presented as a percentage of the number which emerged in controls.

Results are given in Table 1.

TABLE I. EMERGENCE OF WEED SEEDS IN SOIL TREATED UNDER GASTIGHT CONDITIONS

Common Name	Specific Name	Control (% germination of seeds sown)	Percentages survival of weed seeds calculated on basis of percentages emergence in controls for concentration of fumigant indicated:								
			Chloropicrin			D-D		Carbon Disulphide			
			12 ml.	6 ml.	3 ml.	12 ml.	6 ml.	3 ml.	36 ml.	18 ml.	9 ml.
Australian flax	Linum marginale	79	0	0	0	0	0	0	4	0	0
Barnyard grass	Panicum crus-galli	27	0	66	0	9	100	100	0	37	75
Birdsfoot trefoil	Lotus corniculatus	22	0	0	0	0	0	0	34	12	0
Blue-eyed grass	Sisyrinchium angustifolium	67	0	0	0	0	0	53	29	0	90
Bristly mallow	Modiola caroliniana	33	0	0	0	7	0	0	3	0	0
Broad leaved dock	Rumex obtusifolius	43	0	0	0	2	0	0	0	0	0
Broom rape	Owbanche minor	65	0	0	0	0	0	0	3	0	0
Bur clover	Medicago hispida	55	0	0	20	0	0	0	0	0	100
Caper spurge	Euphorbia lathyris	57	0	0	0	0	0	0	12	0	0
Catchfly	Silene gallica	78	0	0	0	1	5	17	19	84	100
Catsear	Hypochoeris radicata	55	0	0	0	0	16	0	0	52	0
Celery-leaved buttercup	Ranunculus sceleratus	15	0	0	0	7	14	24	20	46	100
Charlock	Sinapis arvensis	60	0	0	0	0	0	0	0	0	0
Chewing fescue	Festuca saburicula	24	0	0	0	0	50	0	0	0	67
Chickweed	Stellaria media	39	0	0	0	0	0	0	0	0	0
Cleavers	Galium aparine	28	0	0	0	0	0	0	0	0	0
Clustered dock	Rumex conglomeratus	61	0	0	0	0	0	0	0	0	0
Creeping bent	Agrostis stolonifera	97	0	0	0	0	0	0	0	0	0
Creeping crowfoot	Ranunculus repens	79	0	0	0	6	14	16	10	16	100
Creeping thistle	Cirsium arvense	52	0	0	0	0	0	0	0	0	0
Curled dock	Rumex crispus	98	0	0	0	4	0	0	0	0	0
Dandelion	Taraxacum officiniale	87	0	0	0	6	5	8	16	52	100
Doab	Cynodon dactylon	12	0	0	0	0	42	0	0	84	0
Clovers	Trifolium spp.	100	24	78	99	59	90	100	79	92	100
Fat-hen	Chenopodium album	19	0	23	31	0	0	0	7	14	48
Fennel	Foeniculum vulgare	26	0	0	0	0	0	0	0	0	0
Fumatory	Fumaria officinalis	31	0	0	0	0	0	0	4	0	0
Greater birdsfoot trefoil	Lotus uliginosus	35	0	0	0	0	14	0	0	0	0

TABLE I (Continued)

Greater plantain	Plantago major	96	0	0	0	0	4	11	8	11	100
Groundsel	Senecio vulgaris	26	0	0	0	0	0	0	0	0	0
Hawkweed	Crepis capillaris	74	0	0	0	0	5	0	0	14	0
Hedge mustard	Sisymbrium officinale	30	0	0	0	0	0	0	0	0	0
Italian rye-grass	Lolium italicum	51	0	28	20	0	100	100	0	43	90
Meadow fescue	Festuca pratensis	14	0	18	87	47	8	0	0	8	0
Melilot	Melilotus spp.	8	0	0	0	8	0	0	0	0	0
Milkweed	Euphorbia peplus	62	0	0	0	0	0	0	7	0	0
Moth mullin	Verbascum virgatum	19	0	0	0	0	0	0	0	0	0
Nettle leaved goosefoot	Chenopodium murale	50	0	0	0	0	0	0	0	0	0
Ox-eye daisy	Chrysanthemum leucanthemum	42	0	0	0	0	0	0	0	15	0
Oxtongue	Picris hieracioidis	16	0	0	0	0	0	0	0	0	0
Pepper cress	Lepidium campestre	78	0	0	0	0	0	0	0	17	100
Poa	Poa pratensis	15	0	0	0	0	32	42	0	44	100
Ragwort	Senecio jacoboea	32	0	0	0	0	0	0	0	17	0
Ratstail	Sporobulus capensis	77	0	15	0	0	0	0	0	0	0
Red fat-hen	Chenopodium rubrum	62	0	0	33	0	0	0	0	0	0
Ribgrass	Plantago lanceolata	57	0	0	91	76	0	0	0	38	0
Scarlet pimpernel	Anagallis arvensis	52	0	0	0	0	0	0	0	32	0
Sheep's sorrel	Rumex acetosella	41	0	0	5	0	6	10	11	12	54
Small flowered crowfoot	Ranunculus parviflorus	14	0	0	0	0	0	0	0	0	100
Smooth tare	Vicia tetrasperma	33	0	0	0	8	0	0	0	28	37
Sowthistle	Sonchus oleraceus	18	0	0	0	4	16	47	7	30	57
Spear thistle	Cirsium lanceolatum	22	0	0	0	0	0	0	0	0	0
Stinking mayweed	Anthemis cotula	82	0	0	0	0	0	0	0	0	0
Storks bill	Erodium circutarium	55	0	0	0	0	0	0	0	0	0
Subterranean clover	Trifolium subterraneum	65	0	39	91	0	0	100	85	92	100
Suckling clover	Trifolium dubium	24	0	5	36	0	28	100	73	15	65
Tarweed	Odontitis viscosa	25	0	0	0	0	5	17	0	28	37
Vetch	Vicia sativa	12	0	0	0	0	0	0	18	54	100
Wireweed	Polygonum aviculare	6	0	0	0	16	11	36	6	38	100
Yorkshire fog	Holcus lanatus	13	0	0	66	0	100	54	0	43	80

B. *Treatment of Large Amounts of Soil*: Weed seeds were mixed with 2 cu. ft. of steamed soil, after which the soil was treated with chloropicrin and with D-D at 3 ml. per cu. ft. and carbon disulphide at 9 ml. per cu. ft. Forty-eight hours after treatment the soil was spread in a 2-in. layer over a glasshouse bench and total numbers of weeds emerged were recorded.

The following weed seeds were used, numbers of each species being given in parenthesis: Redshank (30), Hawkweed (50), Dock (60), Fennel (70), Plantains (90), Scarlet Pimpernel (100), Sheeps Sorrel (100), Groundsel (120), Fat Hen (120), Cats ear (140), Buttercups (150), granes (160), plantains (190) and thistles (210).

Of a total of 1,410 weed seeds used, 1,364 weeds emerged in control, 1,263 in carbon disulphide, 247 in D-D, and 11 in chloropicrin-treated soil.

II. *Survival of Weeds in Nursery Soil*

A. *Soil fumigated in closed containers*: Nursery soils (volcanic and clay loam types), from growers' properties were treated in drums, 3 cu. ft. of soil being used for each treatment. Materials were applied at the rate of 3 ml. per cu. ft. of soil. Forty-eight hours after treatment soil was placed into nursery flats, there being 12 flats per treatment. Percentage survival of weeds from treatments was calculated from the number of plants of each species which emerged in controls.

Chloropicrin: 18% Buttercups, 17% Hawkweed, 64% clovers, 22% Plantains, and 54% grasses survived treatment.

D-D: 36% Buttercups, 42% Hawkweed, 71% clovers, 32% plantains, 56% grasses and 50% thistles survived treatment.

Chloropicrin plus D-D (50 to 50 mixture by volume): 28% Buttercups, 26% Hawkweed, 68% clovers, 14% plantains, and 66% grasses survived treatment.

There was no appreciable difference in treatment effect in the two types of soil.

B. *Soil saturated in flats*: Nursery soil based on volcanic loam was placed in flats and chloropicrin emulsion (3 ml.), D-D emulsion (3 ml.), carbon disulphide emulsion (9 ml.), and Formalin (2%) were applied in 3 pt water per flat. Four flats were treated with each compound. Flats were covered with sacks for 48 hours and then transferred to a glasshouse, the number of weeds emerged being recorded 60 days later. A part of the soil used was autoclaved for 10 min. at 200° F. and then placed into flats.

Numbers of weed plants emerged per flat in the various treatments were as follows: control, 35; steam, 0; chloropicrin, 4; D-D, 9; carbon disulphide, 33; and Formalin, 33.

C. *Soil fumigated in heaps*: Nursery soil in heaps (3 × 6 × 1.5 ft) was injected alternately at 6 and 12 in. depth and at 12 in. intervals, with chloropicrin, D-D, and the chloropicrin plus D-D mixture at 3 ml. per injection. Survival of weed seeds recorded in the various treatments is given as percentage of the number which emerged in controls.

Chloropicrin: 80% clovers, 82% grasses, 5% cress, 50% plantains and 8% Buttercups survived treatment.

D-D: 100% clovers and grasses, 17% Cress, 71% Plantains, and 58% Buttercups survived treatment.

Chloropicrin plus D-D: 100% Clovers and grasses, 4% Cress, 29% Plantains and 18% Buttercups survived treatment.

There was no appreciable difference in the effect of treatments in volcanic and clay-loam-based nursery soils.

III. *Survival of Weeds in Glasshouse Soil treated "in situ"*

Glasshouse soil was treated with various fumigants at 3 ml. per sq. ft. Survival of weeds in the various treatments is given as percentage survival of weeds in controls.

Chloropicrin: 2% Sheeps sorrel, 2% Fat hen, 39% grasses, and 3% Dandelion.

D-D: 4% Sheeps sorrel, 2% Catchfly, 7% Sowthistle, 67% grasses, 5% Dandelion, 40% Cress, and 7% Tares.

Chloropicrin plus D-D: 42% grasses and 19% Cress.

Iseobrome II: 35% grasses and 16% Cress.

Chloropicrin plus Iseobrome II (50 to 50 mixture by volume): 43% grasses and 17% Cress.

In three glasshouses where soil was treated with 3 ml. chloropicrin or D-D, the following average numbers of weeds were counted per sq. ft.: Control: 33, 19 and 8 respectively; chloropicrin: 13, 12 and 3 respectively; and D-D: 23, 16 and 6 respectively.

CONCLUSION

From tests not reported here and observations taken on growers' properties, it was evident that disinfection of the soil by steam completely controlled weeds if the method of application was thorough.

Soil fumigants and disinfectants were not found to be highly effective in controlling weeds in nursery and glasshouse soils. Some species of seeds such as clovers and grasses proved highly resistant to chemical disinfection. Of the chemicals tested, chloropicrin and D-D were more effective than others in reducing weed population, but did not completely inhibit germination of seeds. Iseobrome II, which contains 15% methyl bromide, was no more effective than chloropicrin, which, in general, gave best results.

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SEED DISINFECTION

VI. SURFACE DISINFECTION OF VEGETABLE SEEDS

By H. Jacks, Plant Diseases Division, Department of Scientific and Industrial Research, Auckland

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Summary

A survey of the incidence of fungi and bacteria on several varieties of vegetable seeds was carried out by isolations from ungerminated seeds and from seedlings grown in autoclaved soil.

The efficiency of Cuprocide, Spergon, Panogen, thiram, ferbam, Dow 9 B and 36 L for surface disinfection of seeds was compared with the laboratory methods of washing seeds in running water or dippping in: (a) mercuric chloride; (b) acidulated mercuric chloride; and (c) methylated ethyl alcohol.

Panogen and Spergon compared favourably with acidulated mercuric chloride in effecting surface disinfection without depressing germination.

Introduction

Seeds, in general, carry a number of saprophytic and pathogenic fungi and bacteria which are lodged either on the surface or within the seed coat. The efficiency of seven seed protectants in inhibiting the growth of fungous and bacterial flora of vegetable seeds was compared with a number of laboratory methods commonly used.

Experimental Methods and Results

Vegetable seeds were drawn from samples used previously (Jacks, 1951).

Laboratory methods used for surface disinfection of seeds were as follows: (1) washing for one hour under fast running tap water; (2) soaking for 10 minutes in 0.1 per cent solution of mercuric chloride dissolved in warm distilled water; (3) soaking for 10 minutes in 0.1 per cent acidulated mercuric chloride (1g. mercuric chloride in 2.5 ml. concentrated hydrochloric acid to 1000 ml. distilled water); and (4) soaking for 10 minutes in methylated ethyl alcohol. After treatment by these methods seeds were washed in 8 to 10 changes of sterile distilled water and dried between layers of sterile filter paper.

Commercial materials used in these trials have been described previously (Jacks, 1951).

Accurate dosages of dusts, or liquids as percentages of seed weight, were weighed or pipetted and applied to small quantities of seeds, even distribution being ensured by shaking both in a conical flask for five minutes.

Soil was autoclaved for two hours at 25 lb pressure, air-dried and stored for 14–20 days before use.

Three hundred seeds of each vegetable were sown at depths of 1.2 cm for small, 2 cm for beet and 3 cm for large seeds. Isolations were made from seedlings and from ungerminated seeds 15–30 days after emergence.

Three hundred seeds of each vegetable and 100 isolations from seedlings grown in autoclaved soil were plated out on malt agar. Petri dishes plated out with celery seed are shown in Fig. 1.

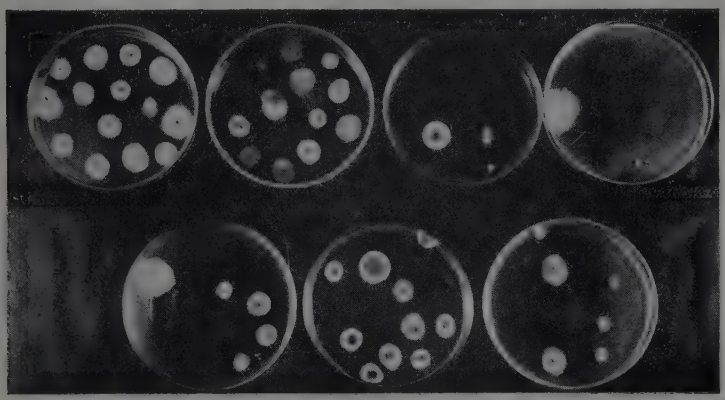

FIG. 1.—Effect of some seed dressings on incidence of fungi on celery seed. From left to right: Top Row—Control, Cuprocide, Spergon and Panogen. Bottom Row—thiram, ferbam and Dow 9 B.

Where necessary, mixed colonies were separated by using the hyphal tip technique (Brown, 1924).

RESULTS

Table I show larger numbers of organisms recorded from plating tests than from isolations from seedlings grown in autoclaved soil.

TABLE I. INCIDENCE OF FUNGI AND BACTERIA ON UNTREATED VEGETABLE SEEDS
(Figures showing the percentage of seeds from which respective organisms were isolated)

Organisms	Lettuce		Pea		French Bean		Turnip		Beet		Tomato		Celery	
	Plate Tests	Soil Tests	Plate Tests	Soil Tests	Plate Tests	Soil Tests	Plate Tests	Soil Tests	Plate Tests	Soil Tests	Plate Tests	Soil Tests	Plate Tests	Soil Tests
Botrytis spp.	16	0	8	0	12	0	11	0	22	0	2	0	3	0
Fusarium spp.	9	9	19	4	16	0	18	5	13	11	83	4	16	1
Rhizoctonia spp.	7	3	4	0	3	1	0	1	0	1	0	0	0	1
Alternaria spp.	10	8	10	0	12	2	16	4	5	3	19	5	4	4
Stemphylium spp.	2	0	14	0	1	0	0	0	0	0	0	0	0	0
Pullularia spp.	46	26	9	0	11	0	87	0	24	0	15	0	4	1
Penicillium spp.	27	0	92	2	78	10	100	0	45	12	48	0	51	4
Cladosporium spp.	27	0	5	0	12	4	3	0	10	2	0	0	3	0
Trichothecium spp.	10	0	15	0	0	0	0	0	5	0	0	0	3	0
Mucor spp.	12	12	13	0	13	0	7	0	13	3	10	0	5	0
Thamnidium spp.	1	0	3	0	0	0	0	0	0	0	0	0	0	0
Cephalosporium spp.	1	0	4	0	0	0	3	0	0	0	0	0	0	1
Rhizopus spp.	8	0	9	0	8	0	2	0	2	0	6	0	0	0
Aspergillus spp.	1	0	3	0	0	0	0	0	0	0	0	0	0	1
Ascochyta spp.	0	0	8	0	0	1	0	0	0	0	0	0	0	0
Colletotrichum spp.	0	0	0	0	0	3	0	0	0	0	0	1	0	0
Phoma spp.	0	0	0	0	0	0	18	7	18	13	6	0	7	7
Septoria spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miscellaneous spp.	28	0	11	0	14	0	14	1	81	2	21	1	23	5
Bacteria spp.	25	18	18	9	14	9	9	6	9	8	21	27	14	1
Clean seeds or healthy seedlings	0	51	6	81	0	71	0	51	0	70	0	41	0	81
Germination or Emergence	83	91	85	91	83	91	51	74	144*	143*	49	82	10	47

* Percentage germination or emergence of beet seed from 100 seed balls

It appears that plating seeds on agar encourages certain rapidly growing fungi which in themselves have little significance for germination.

Tests, similar to those described above, were carried out with seeds treated by laboratory methods and with seed dressings. The latter were applied at the following concentrations (expressed as percentages of seed weight): lettuce, 0.5; pea, 0.25; French bean, 0.125; turnip, 0.5; beet, 0.5; tomato, 1.0; and celery, 0.5 per cent. As isolations from seedlings gave a relatively small number of organisms, the effect of treatments was assessed on the basis of results from plating tests only. Effect of seed treatments on viability of seed and in reducing incidence of fungi and bacteria is shown in Table II.

TABLE II. EFFECT OF LABORATORY METHODS AND COMMERCIAL SEED DRESSINGS ON INCIDENCE OF SEED-BORNE FUNGI AND ON GERMINATION OF SEEDS
(Given as percentage clean seeds and percentage germination.)

Treatment	Lettuce		Pea		French bean		Turnip		Beet		Tomato		Celery	
	Clean Seeds	Germination	Clean Seeds	Germination	Clean Seeds	Germination	Clean Seeds	Germination	Clean Seeds	Germination	Clean Seeds	Germination	Clean Seeds	Germination
Control	0	65	6	83	0	95	0	49	3	153	0	22		13
Running water	0	93	0	92	0	89	0	51	0	140	0	67	13	17
$HgCl_2$	57	96	80	93	72	100	52	79	70	132	49	92	21	40
Acidulated $HgCl_2$	71	46	77	95	87	100	66	70	69	70	44	60	20	23
Methylated Alcohol	11	34	80	93	65	100	80	75	63	0	57	91	52	39
Cuprocide	0	95	5	96	60	100	0	60	72	174	0	55	36	0
Spergon	85	97	81	94	95	100	95	75	84	144	34	56	61	18
Panogen	92	95	82	96	100	100	92	73	84	102	56	64	70	0
Thiram	63	99	85	97	95	100	70	69	95	174	62	71	70	0
Ferbam	70	90	80	95	85	99	77	69	88	156	40	72	58	0
Dow 9 B	45	90	70	90	92	100	73	69	88	150	72	78	62	0
36 L	38	95	67	97	63	100	-	95	42	126	4	62	55	44

Judging from the percentage of clean seeds, the most effective agents for seed disinfection were Panogen and Spergon, which compared favourably with treatments of seeds (except celery) with acidulated mercuric chloride. Thiram and ferbam were effective against many organisms but ineffective against bacteria. The three remaining proprietary substances were less effective. Treatment of seeds with acidulated mercuric chloride and with methylated ethyl alcohol had a depressing effect on germination of lettuce and beet, a fault which none of the proprietary substances showed. However, most proprietary seed dressings depressed germination of celery. None of the treatments was effective in preventing the growth of *Ascochyta* or *Mycosphaerella* on pea seed, but reduced *Fusarium* infection which may cause rotting of seed. Bacterial contamination of bean seed was reduced by Spergon and Panogen, thus preventing seed decay. With turnip, no treatment eliminated *Phoma*. Infection with *Alternaria*, which according to Dennis (1939) caused considerable damage to turnip seedlings, was however reduced by Spergon, Panogen and thiram. With beet, Spergon, Panogen, thiram, ferbam and Dow 9 B compared favourably with laboratory methods as regards reduction in the incidence of *Phoma*. Seed dressings, other than Cuprocide and 36 L, compared favourably with laboratory methods in controlling seed borne fungi on tomato seed. Spergon, Panogen, 36 L and Dow 9B reduced bacterial contamination. Though pycnidia were present on 1.3 per cent of the celery seed used (Table I), no growth of *Septoria* occurred. This may have been due to the fact that the seed

was more than two years old, as Campanile (1926) found that conidia of *S. apii* have a reduced germination capacity in the second year, and do not survive for a third season. Seed dressings were not as effective as acidulated mercuric chloride and methylated alcohol in reducing seed-borne flora on celery seed.

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PHOSPHATE-UPTAKE STUDIES WITH RADIOACTIVE PHOSPHORUS

By K. Strzemieński, Soil Bureau, Department of Scientific and Industrial Research, Wellington

(Received for publication, 21 November 1952)

Summary

In pot experiments with perennial ryegrass, uptake from the soil and radioactive fertilizer was studied; some observations suggest that isotopic exchange between soil and fertilizer may influence results. In spite of this, the results are unmistakable in showing the utter dependence of the plants on fertilizer phosphate if grown on soils as low in available phosphate as the soils used. Their phosphate availability can be regarded as representative of a vast number of soils commonly met with in New Zealand.

Introduction

In an experiment with radioactive phosphate applied to soils highly deficient in available phosphate, the soil phosphate uptake from fertilized pots was found to be strikingly higher than in controls. These results have been briefly reported elsewhere by the writer (1948). When McAuliffe *et al.* (1948) reported *in vitro* experiments demonstrating possible extents of isotopic exchange, further experiments were designed to find out whether the previous observations were caused by isotopic exchange or by a genuine physiological reaction.

Experimental Methods

Common earthenware pots of about 12 cm. (5 in.) top diameter and height, paraffin-waxed and brought to equal weight by means of gravel placed in the bottom, were used in the experiments reported in this paper. The pots hold from 400 to 600 g. of soil on dry-matter basis. The pots were sown with perennial ryegrass and kept in a glasshouse. They were watered to about ⅔ of water-holding capacity. A basal dressing containing all nutrient elements except phosphorus was applied in all experiments. After emergence the soil was covered with coarse sand to facilitate watering and to avoid crust formation.

Experiment 1

Two soils were used: a red loam derived from basalt—the Maunu loam—and a mature podzol derived from silicious claystone —the Wharekohe silt loam (Table 1). The experiment was designed to include monocalcium phosphate (with and without lime) and reverted phosphates. The fertilizers were mixed with the whole soil of each pot. Lime, where used, was given in amounts calculated to bring the exchangeable calcium to 70 per cent of exchange capacity. The reverted phosphates were prepared by grinding the monocalcium phosphate samples (0.18 g.) with 0.15 g. calcium carbonate or 0.16 g. magnesium carbonate in a mechanical mortar. The hydrated monocalcium phosphate was prepared from an impure ammonium phosphomolybdate obtained from an irradiated copper-phosphorus target and kindly supplied to the N.Z.

TABLE I. CHEMICAL ANALYSES OF SOIL

Classification*	Type	Depth (in.)	pH	1% Citric Acid Soluble P_2O_5 (%)	Organic C (%)	Total N (%)	C/N	Exchangeable Cations				
								Exchange Capacity (m.e.%)	Total Bases (m.e.%)	Base Satn. (%)	Ca (m.e.%)	Mg (m.e.%)	K (m.e.%)
Red loam	Waunu silt loam	0-6	5.7	0.009	8.2	0.57	14	29.6	14.6	49	9.7	4.3	1.0
Podzol (strongly weathered)**	Wharekohe silt loam	0-6	5.2	0.001	3.0	0.14	21	0.6	2.4	28	1.0	1.20	0.20
Yellow-brown earth (moderately weathered)	Kaitoke silt loam	0-6	5.1	0.006	4.2	0.24	18	16.0	4.6	29	3.4	1.2	0.48

* Soil Map of New Zealand, (1948), N.Z. Dep. Sci. Ind. Res. Soil Bureau.

** Cf. W.H. Taylor, J.K. Dixon and F.T. Scelye: The Soils of North Auckland Peninsula, New Zealand. Trans. IV Inter. Congress of Soil Science, Amsterdam 1950, 1:293-6.

Department of Scientific and Industrial Research by the Terrestrial Magnetism Laboratory, Carnegie Foundation, Washington, D.C. An inert control sample of primary calcium phosphate was prepared at the same time and used for Treatment V. (Table 2). The phosphates were applied in amounts equivalent to 100 mg. P_2O_5 per pot. Treatment VIII received in addition 6 mg. P_2O_5 as a monosodium phosphate solution, 0.1 ml of which was placed beneath each seed. Six replicates per treatment were provided. The activity of the labelled phosphate was approximately 100 microcuries (μc.) per gram of P_2O_5 at sowing time.

Pots were sown on 3 August 1947, thinned to 7 plants per pot, and harvested on 22 and 23 October 1947.

The dried samples were weighed and after wet combustion with perchloric and nitric acids, the phosphorus content was determined by the gravimetric method of Lorenz (1901), with acetone drying as introduced by Neubauer and Lücker (1912). The ammonium phosphomolybdate precipitates obtained in this procedure were dissolved with ammonia and the sintered glass crucibles reweighed. The ammoniacal filtrates containing the radioactive material were collected in Pyrex glass dishes 6.5 cm in diameter and 5 cm height, standardized potassium carbonate solution added, the dishes heated on the water bath to expel ammonia, and enough water added to make the solution weigh 6 g. net. These dishes with the solution were used for radioactivity measurements. The weights were checked from time to time and, if necessary, water added to restore weight. Similar solutions obtained from the radioactive primary calcium phosphate were used as standards. Background counts were always made with a dish filled with a corresponding amount of potassium carbonate and water. The presence of potassium slightly increased the background, but the higher solubility of the carbonate and the molybdate of potassium made this element preferable to sodium. Radioactivity measurements were made with an end-window Geiger-Müller counter. Results are shown in Table II.

Experiment 2

The same Wharekohe silt loam was used as in Experiment 1 (see Table 1). A solution containing two molecules of monoammonium phosphate to one molecule of diammonium phosphate, labelled with a radioactive phosphate (a separated isotope from the

TABLE II. POT EXPERIMENT WITH PERENNIAL RYEGRASS GROWN FOR SEVENTY-NINE DAYS
(Means of six replicates)

Treatment	I	II	III	IV	V	VI	VII	VIII	IX	X
	Maunu silt loam								Wharekohe silt loam	
	Control	Control + $CaCO_3$	R.A. Monocalcium phosphate	R.A. Monocalcium phosphate + $CaCO_3$	Inert Monocalcium phosphate + $CaCO_3$	R.A. Monocalcium phosphate reverted with $CaCO_3$	R.A. Monocalcium phosphate reverted with $MgCO_3$	Like No. IV but + 6 mg P_2O_5 beneath seeds	Control + $CaCO_3$	R.A. Monocalcium phosphate + $CaCO_3$
RESULTS										
Yield: (mg./pot)										
Tops, sand-free d.m.	64	49	948	792	950	675	804	828	64	1,120
Roots, sand-free d.m.	59	52	718	635	783	592	671	669	77	1,087
Total yield (tops and roots)	123	101	1,666	1,427	1,733	1,267	1,475	1,497	141	2,207
P_2O_5 (mg./pot)										
Tops										
Fertiliser P_2O_5	-	-	4.58	3.83	-	3.03	3.35	3.51	0	9.83
Soil P_2O_5	0.19	0.09	0.66	0.21	-	0.59	0.91	0.60	0.16	1.57
Total P_2O_5	0.19	0.09	5.24	4.04	4.75	3.62	4.26	4.11	0.16	11.40
Roots										
Fertiliser P_2O_5	-	-	2.84	2.36	-	1.93	2.06	1.95	0	6.08
Soil P_2O_5	0.12	0.09	0.32	0.34	-	0.62	0.65	0.71	0.11	0.85
Total P_2O_5	0.12	0.09	3.16	2.70	3.18	2.55	2.71	2.66	0.11	6.93
Whole Plants (tops and roots)										
Fertiliser P_2O_5	-	-	7.42	6.19	-	4.96	5.41	5.46		15.91
Soil P_2O_5	0.31	0.18	0.98	0.55	-	1.21	1.56	1.31	0.27	2.42
Total P_2O_5	0.31	0.18	8.40	6.74	7.93	6.17	6.97	6.77	0.27	18.33
pH after harvest	5.02	5.09	6.81	6.39	6.38	5.79	5.89	6.35	7.84	7.40

$S^{32}n.p,P^{32}$ reaction) was used as fertilizer, applied in amounts of 100mg. P_2O_5 per pot, contained in 2 ml of the solution, which was added to the respective amount of soil in small drops, spread as well as possible, and the soil thoroughly mixed. Controls received an equivalent amount of nitrogen as ammonium sulphate. Calcium carbonate and basal dressing were added to the soil in bulk and much ahead of potting. pH was 6.0 at time of potting. Radioactivity was about 400 mc. per gram of P_2O_5 at seeding time.

Twenty seeds were sown per pot (thinned later to sixteen) on 29 December 1948. Of the eight replicates per treatment, four were harvested on 7 February 1949, and the other four on 13 April 1949, i.e. after 40 to 105 days respectively. (Table III.)

The dry matter and phosphorus contents were determined as in the prevous experiment. From the ammoniacal solutions of the ammonium phosphomolybdate, ammonium magnesium phosphate was precipitated. If, as usually, one or a pair of standards had to serve for a series of samples, the latter were made up to the amount of P_2O_5 contained in the standard. For this purpose necessary amounts of a phosphoric acid solution of known strength were added to the samples before the ammonium-magnesium-phosphate precipitation. In this way, within each series the standards and samples produced the same amount of precipitate, corrections for self-absorption were thus eliminated and counts could be directly compared. The precipitates were collected in sintered-glass filters, 3 cm in diameter and 2 cm overall height, made especially for this purpose. These procedures will be described more fully elsewhere.

Experiment 3

The soil used was a yellow-brown earth from Silverstream, the Kaitoke silt loam. Labelled monopotassium phosphate solution supplying either 20 or 100 mg. P_2O_5 per pot was applied as fertilizer. (Table IV). At either rate, the fertilizer was mixed with the whole 700g. of the soil or with 160g. of the soil placed around a core of sheet iron shaped as a truncated cone. When potting the soil, first a little of the untreated soil was put directly on the gravel, then the core placed in position with sides parallel to the sides of the pot, and the narrow space between pot and core filled with the phosphate-treated 160g. of soil with just enough compression to make it stay in place when the core was withdrawn. The central space and a few centimeters on top of the treated soil were filled with the untreated soil. Thus, the phosphate was confined to the space traversed most profusely, and, at an early stage, by the roots. Another way of applying the 20 mg. dose was (Treatment II) to dilute it to 50 ml and apply as a top dressing 16 days after sowing. In all other instances (Treatments III-VI)the phosphate was applied in concentrated solution containing 100 mg P_2O_5 in 1 ml. Nineteen seeds per pot were sown on 2 April 1949, and later singled to 14 plants. Tops were harvested on 18 August 1949. Roots were not collected in this experiment. The initial radioactivity, i.e. at the time of sowing, was 225 μc. per gram of P_2O_5.

Results and Discussion

Experiment 1

Table II shows that the Maunu silt loam gave in all cases an excellent response to the phosphates applied. The controls were obviously starved; fertilized plants gave at least ten times higher yields. Within the phosphate treatments, on the other hand, most differences are not statistically significant. Liming the soil or reverting the phosphate did not improve yield or phosphate uptake. If anything, they depressed both. The direct effect of lime was only moderate as it resulted in a pH of 6.4 at most, as against pH 5.6 unlimed.

The inert-phosphate treatment (V) gave a higher yield than the corresponding radioactive one (IV), this being one of the few statistically significant differences. This result is difficult to explain as the radioactivity—though less exactly known than in later experiments—was by no means excessive. The very slight differences (other than in radioactivity) that there might have been in the nature of the two phosphates cannot supply a convincing explanation since much greater differences in chemical conditions mattered so little. Contamination with a toxic element that escaped purification procedures appeared less improbable, but had to be ruled out on subsequent spectrographic analysis. Various aspects of radiation injury have been discussed in another paper (Strzemienski, 1952).

Yield and phosphate uptake were better on Wharekohe silt loam than on Maunu loam (Treatments IX and X, Table II).

With the very low native phosphate availability in both soils it is but natural that by far the larger part of the phosphate in the plants came from the fertilizer and not from the soil. However, even with the small margin left for the soil phosphate, its absolute amounts in the fertilized plants greatly exceed the phosphate uptake of the controls. This was at first considered to be entirely a result of the much faster and better development of the phosphate-fertilized plants (Strzemienski, 1948). Their root systems were much better developed and it is reasonable to suppose that their physiological processes were also much more vigorous than those of the undoubtedly starved controls. Moreover, Zaleski (1926), without a tracer technique, showed many years ago that very small doses of superphosphate placed just beneath the seed were capable of increasing the phosphate uptake in oats by more than the amount of this nutrient contained in the superphosphate; this could have come about only by an increase in uptake from other sources, i.e. from the soil. Using P^{32} as a tracer, Spinks and Barber (1948) made similar observations with wheat.

McAuliffe *et al.* (1948) made the following interesting experiments: soil samples were shaken with water and the phosphate concentration in the aqueous phase determined colorimetrically. When equilibrium was reached—usually after four days carrier-free P^{32} was added. Radioactivity initially introduced was very high, but chemically the amount of phosphate added was negligible, so that the overall

equilibrium was not disturbed. The diminishing radioactivity of the solution was determined at intervals of time. From its accepted equilibrium value, the initial radioactivity, the soil-to-water ratio and the phosphate-ion concentration at equilibrium, the authors calculated the amount of surface-bound phosphate ion in the soil that takes part in establishing the equilibrium with water. Any such equilibrium is kinetic in nature, i.e. equilibrium prevails when the number of ions leaving the soil-particle surface per unit of time equals that of ions settling on the surface from the solution. The introduced P^{32} ions take part in this continuous exchange and the reach equilibrium when the ratio of P^{32}:P^{31} ions becomes the same in the active surface of the soil as in the solution. The authors' intent was to estimate the amounts of this kind of exchangeable phosphate in the soil; they found values roughly equalling half of those supplied by the modified Truog method or the Neubauer method, in acid and calcareous soils respectively. Their paper did not raise the question of a possible bearing these findings may have upon the interpretation of experiments with P^{32} on fertilizer and soil-phosphate uptake. This writer (1948) expressed the opinion that there is some opportunity for isotopic exchange to proceed when a labelled fertilizer is introduced into the soil. Though it may proceed much more slowly than it does in laboratory experiments of the kind just described, this slower rate may be largely offset by the much longer duration of fertilizer experiments. Whenever isotopic exchange occurs in the soil between the labelled phosphates, derived from the fertilizer by ordinary chemical reactions, on one hand and the soil phosphates on the other hand, the former must lose some of their specific radioactivity. For, the P^{32} ions, originally confined to the amount of fertilizer phosphate, say B, have now been distributed among a larger amount of phosphate. If the amount of soil phosphate taking part in this exchange is represented by A and complete equilibrium is attained, then, if the initial specific radioactivity of the fertiliser was p, it will now be $p' = p\frac{B}{A + B}$. This is the well known isotope dilution formula. If a plant absorbs only fertilizer phosphate, and this has undergone such a reduction in specific activity, analysis and radioactivity determination will show the plant phosphate to be of lower specific activity (p′) than the standard (p)—the latter being a sample of the original fertilizer-phosphate that has had no contact with soil phosphates. What the plant phosphate is lacking in specific radioactivity will be ascribed to soil phosphate taken up. This may be quite erroneous because no matter what the plant actually feeds on—A only, or B only, or on A and B in whatever proportion—the p′ to p ratio will always be the same.

Larsen (1950, 1952) observed that for a given soil the A-value calculated from experimental pots fertilized with primary or secondary calcium phosphate remained constant irrespective of fertilizer doses, but that this was not so with hydroxyapatite. Larsen considers A to be the amount of soil phosphate able to exchange isotopically with the added soluble phosphates. Gunnarsson and

Fredriksson (1952) made similar observations using labelled superphosphate in pot and field experiments, and found the same A-values by extracting the respective soils with dilute labelled phosphate solution for 14 days. These results were in fair correspondence with amounts of available phosphate obtained by the lactate method of Egner. These authors regard the amount of soil phosphate active in the isotopic exchange as identical with the available soil phosphate. They state, however, that the numerical value thus obtained does not "mean the same for different soils when assessing their fertilizer requirement". Fried and Dean (1952) adopted some of Larsen's ideas and the same formula but with a different interpretation. They assume that "when two sources of a given nutrient are present in the soil the plant will absorb from each of these sources in proportion to the respective quantities available". Accordingly, they consider the A-value to be the amount of soil phosphate that is as available as that of the fertilizer. In their opinion, the dilution of this tracer isotope occurs in the plant, not in the soil, because "the movement of phosphate ions in soil is highly restricted, and the two sources of phosphorus—the soil and the standard—can be envisioned as essentially independent". (l.c. p. 269).

In Experiment No. 2 (Table III), incorporating the fertilizer into the upper fifth of the soil gave in both harvests slightly higher yields and very significantly higher phosphate uptakes than mixing the fertilizer with the whole soil. In the second harvest, the phosphate in tops taken from the soil was slightly higher in Treatment III than in II. This would agree with either of the hypotheses discussed above. In either phosphate treatment, at the second harvest the soil phosphate in tops was many times higher than it was in the controls.

In the experiment with the Kaitoke silt loam (Table IV), increasing the fertilizer application from 20 to 100 mg. P_2O_5 did not influence yield, though it considerably increased phosphate uptake. Among the 20 mg. P_2O_5 treatments, Treatment II with the liquid topdressing gave the highest yield and highest phosphate uptake. Treatment III had the fertilizer confined to a small volume of the soil in conditions that made leaching almost ineffective in increasing contact of the fertilizer with the soil. Soil-phosphate uptake was here the lowest of the three treatments. This would suggest that isotopic exchange does influence the apparent soil-phosphate uptake. The A-values shown are much the same for Treatments II and IV, but much lower for Treatment III. This too suggests that the A-value could be taken as a measure of the isotopic exchange capacity of the soil, but—at least in the conditions of this experiment—not as a measure of the available soil phosphate. On the Fried and Dean hypothesis the reduced relative soil-phosphate uptake in Treatment III as compared with Treatments II and IV would result from an increased availability of the fertilizer due to the way it was applied in Treatment III. This is, however, not compatible with the fertilizer phosphate uptake being higher in II than in III. The yields decrease in the sequence of Treatments II, III, IV, and the total

phosphate uptake was highest in II and almost equal for III and IV. This suggests that the phosphate availability was highest in II. Yet the lowest soil-phosphate uptake, both absolutely and relatively, occurs in Treatment III. On the other hand, it is obvious that Treatment III made conditions least favourable for isotopic exchange.

Another instance demonstrating the difficulties encountered in interpreting experimental results by the equal-availability hypothesis alone, may be found in Table 2. The A-value calculated for the Wharekohe silt loam is 16 mg. P_2O_5 per pot, while the whole soil phosphate soluble in 1 per cent citric acid was only 5 mg. per pot; yet the citric acid method is generally believed to yield an exaggerated estimate of available phosphate.

In soils as low in available phosphate as those used in the experiments described in this paper, the small figures obtained for soil-phosphate uptake are likely to be burdened by a high experimental error. All the same, several of the results obtained seem to be much more easily explained by isotopic exchange than by the equal-availability hypothesis.

In most cases the apparent absolute soil-phosphate uptake was substantially higher in plants fertilized with phosphate than in controls. From the evidence obtained, however, it is not possible to decide with certainty whether this was due to a physiological reaction or was simulated or exaggerated by isotopic exchange. Though all three soils used are extremely poor in available phosphate, their isotopic exchange abilities do not appear to be negligible.

Most likely, in all such experiments the isotopic exchange reactions never reach complete equilibrium. But the more available phosphates of the soil, being more or less also the more soluble ones, will approach equilibrium faster. If present, their activity will probably often mask the more slowly proceeding exchanges. Under a great variety of conditions found in farming-soils, results will therefore agree with both hypotheses; viz. isotopic exchange and equal availability. Indeed, if isotopic exchange proceeds with reasonable proportionality to the availabilities of the soil phosphates involved, any distinction between the two hypotheses may be not only impossible but irrelevant. The most promising approach for distinguishing between the two would appear to be experiments with different fertilizer placements. Fried and Dean found, in pot experiments with oats, higher A-values when the monocalcium phosphate was mixed with the whole soil than when it was applied in a band. This fits either hypothesis: the availability of the band-placed phosphate was higher as proved by higher total and fertilizer P_2O_5 uptakes at least in the Davidson soil; in agreement with the equal availability principle the A-value, i.e. the amount of soil phosphate that could match the fertilizer in availability, was smaller. On the other hand, the fertilizer in bands had contact with a much smaller volume of soil and therefore had much less opportunity for exchange reactions with the soil phosphates. With both placements the A-values

TABLE III. POT EXPERIMENT WITH PERENNIAL RYEGRASS GROWN ON WHAREKOHE SILT LOAM
(Means of four replicates)

TREATMENT	Harvested after 40 days			Harvested after 105 days		
	I	II	III	I	II	III
	Control	100 mg. in 1/5 top soil	100 mg. to whole soil	Control	100 mg. in 1/5 top soil	100 mg. to whole soil
RESULTS						
Yield, d.m. (g.)						
Tops	0.08	1.53	1.22	0.22	3.63	3.00
Roots	0.10	1.17	1.10	0.29	3.84	3.35
Whole plants	0.18	2.70	2.32	0.51	7.47	6.35
Total P_2O_5 taken up (mg.)						
Tops	0.15	13.49	9.25	0.24	16.27	11.41
Roots	0.14	7.00	6.31	0.32	11.73	9.38
Whole plants	0.29	20.49	15.57	0.56	28.00	20.79
P_2O_5 from fertilizer (% total P_2O_5)						
Tops	0	97.5	100	0	93	85
Roots	0	100	100	0	100	100
Soil P_2O_5 in tops (mg.)				0.24	1.2	1.7

increased, however, with increasing rate of application, and this was much more prominent with the band placement. It is difficult to bring this into accord with these authors' hypothesis because from what is known about phosphate fixation in soils the potential, i.e. chemical, availability of the fertilizer phosphate should increase with increasing fertilizer-to-soil ratio. The authors' explanation is that the accessibility to plants of phosphorus added in the band does not remain constant; this probably means that at high rates the fertilizer phosphate spreads out and a part of it is further away from the plants. This is not a wholly convincing explanation. On the other hand it is obvious that, unless the fertilizer is applied in solution, however carefully it be mixed with the soil, the mixture is never perfect. There always remain small spaces in the soil without the fertilizer. Under the influence of moisture the particles or clusters of particles will dissolve, and the solute diffuse away; but, such diffusion being limited in extent, there will still

TABLE IV. POT EXPERIMENT WITH PERENNIAL RYEGRASS GROWN ON KAITOKE SILT LOAM FOR 138 DAYS
(Means of four replicates)

TREATMENT						
Treatment No.	I	II	III	IV	V	VI
Method of applying phosphate	No P_2O_5	20 mg. P_2O_5 Dilute solution topdressing	20 mg. P_2O_5 "Around core"	20 mg. P_2O_5 Whole soil	100 mg. P_2O_5 "Around core"	100 mg. P_2O_5 Whole soil
RESULTS						
Yield (dry matter) (g.)	0.23	1.70	1.42	1.29	1.61	1.51
P_2O_5 uptake total (mg.)	0.37	3.22	2.32	2.44	6.30	6.13
from fertilizer (mg.)	-	2.38	2.06	1.78	5.45	5.18
from soil (mg.)	0.37	0.84	0.25	0.66	0.85	0.95
P_2O_5 from fertilizer (f)*	0	74%	89%	73%	86.5%	84.5%
from soil (s)*	100%	26%	11%	27%	13.5%	15.5%
$A = \frac{s}{f} \times P_2O_5$ added (mg./pot)		7.0	2.5	7.4	15.6	18.1

* Expressed as percentage of total phosphate

remain small volumes of soil that have no contact with the fertilizer. With increasing rate of application, the volume of soil that has contact with the fertilizer will increase; therefore, the extent of isotopic exchange can also increase. Similar considerations apply to restricted placements, such as in bands, where increasing rates will saturate larger volumes of soil above their retention capacity, and thus increase the contact volume of soil.

All this is not meant to question the fundamental soundness of Fried and Dean's belief that, from two different sources, plants will absorb amounts that are one to the other in the same proportion as the products of availability and quantity of each source. Indeed, if the resultant or over-all availability is considered, no better basis for a definition of availability could be conceived. (However, this definition is valid only if restricted to very short periods of time, since plants can take up equal amounts of a nutrient on two different treatments but give a higher yield on the treatment where they can take up the nutrient at an earlier stage of their development.) Neither is it the intent to doubt the reality of such phenomena as an increased soil-phosphate uptake caused by a phosphate fertilizer. The main subject of this discussion is whether fertilizer experiments with tracer elements always give a true picture.

In connection with this an important point that seems to have been forgotten ought to be recalled. McAuliffe *et al.* (1948) found that there were two different exchange reactions involved in their *in vitro* experiments, one logarithmic, the other linear. This became apparent when the ratio of radioactivity in the soil surface to the radioactivity in the solution was plotted against time. For the purpose of determining the easily exchangeable phosphate they eliminated the influence of the constant-rate reaction. Hendricks and Dean (1948) when speaking of these experiments said: "The nature of the zero order reaction is unknown at the present time. It is, however, of deep significance in soils work and great interest attaches to its clarification. Here is the true nature of 'fixation' in acid soils". This means that in this slow exchange reaction, much larger amounts of soil phosphate may be active than those involved in the logarithmic reaction. In other words, that the capacity for isotopic exchange may be many times greater than the moderate amounts of "available" phosphate would suggest.

What matters here is whether isotopic exchange does occur between the introduced phosphate and such soil phosphates that are negligible sources of this nutrient for the growing plant. The above-quoted experiment of McAuliffe *et al.* would suggest that this is quite possible. Such an isotopic exchange must act as a trap or sink draining away the radioactivity and feigning a contribution to the nutrition of the plant from the soil phosphate. Fried and Dean in experiments with radioactive calcium found, in all three soils used, higher figures for the calcium A-values than for the exchangeable calcium. This also would support the view that compounds probably incapable of supplying an available nutrient can take part in isotopic exchange to a measurable degree.

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CHEMICAL COMPOSITION OF SOME TUSSOCK GRASSLAND PASTURES

By I. E. Coop, M. Darling and C. M. Anderson, Canterbury Agricultural College, Lincoln

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Summary

The chemical composition of the following pasture material is reported:

(i) Mixed pasture from a number of South Island hill country areas;

(ii) Individual species from a single high country tussock grassland area;

(iii) Individual species throughout the growing season from another high country tussock grassland area.

The results show that in general calcium levels in the herbage are satisfactory, but that protein, phosphorus and copper levels are very low except in the spring. Blue tussock is superior in composition to fescue tussock, though both have a very low nutritive value. The different species of grasses have much the same composition at equivalent stages of growth. They suffer a rapid decline in nutritive value after the spring, and remain low in value for considerable periods. The clovers and catsear have a somewhat similar chemical composition and both are much superior to the grasses.

The need for further work, especially with animals, is emphasised.

Introduction

The nutritive value of the highly improved ryegrass-clover type pastures on the dairy and fat-lamb country of New Zealand is reasonably well known. This country is usually topdressed regularly with lime and superphosphate and is subjected to intensive grazing management. The chemical analysis and digestibility of these pastures show them to be of high nutritive value at most periods of the year and to contain ample protein, calcium and phosphorus.

In contrast to this, our knowledge of the nutritive value of the pastures on the very extensive area of hill country is extremely limited. Most of what is known is due to Aston (1928-31) and Aston *et al.* (1931). While investigating the relationship between stock health and the mineral content of pasture, they analysed a considerable number of pasture samples from the Waikato, Poverty Bay, Wairarapa and Canterbury. A large proportion of these were lowland and not hill pastures and some had been topdressed. The most notable feature of the analyses was the low phosphorus level observed in several of the Wairarapa pastures. These low values were obtained in midsummer and were associated with conditions of drought. Rigg and Askew (1930) in the same period analysed some Moutere hill pastures in the Nelson district, but found no outstanding features. As far as the large area of some 12–15 million acres of high country tussock grassland is concerned, no analyses have as yet been reported. The present work was therefore undertaken to extend our knowledge into this field.

The investigation has taken the following form:

(i) a preliminary survey of some South Island hill and high country pastures in spring and summer in regard to their chemical analysis;

(ii) analysis of individual species, in spring, summer and winter, from one site (Cass) in the high country tussock grassland;

(iii) analysis of individual species, throughout the growing season, collected from an ungrazed area (near Lake Coleridge) in the high country tussock grassland.

Protein and Mineral Requirements of Sheep

The chemical analyses to be given must for interpretation be considered in relation to the requirements of the sheep grazing the pastures. The recommendations of the National Research Council of U.S.A. (1945), which are based on a survey of all available literature, place the minimal calcium and phosphorus requirements expressed as the percentage in the dry matter of the feed as follows:

Calcium, 0.22 per cent for dry sheep, increasing to 0.33 per cent for lactating ewes; phosphorus, 0.18 per cent for dry sheep, increasing to 0.24 per cent for lactating ewes.

The copper requirements of sheep are not known accurately under all environments. Pasture from the peat soils of New Zealand was found by Cunningham (1946) to be deficient if it contained less than 8 p.p.m., whereas Bennetts and Beck (1942) in Australia consider that pasture with levels of 3–5 p.p.m. was marginal and below 3 p.p.m. was deficient. Differences in soil type, pasture species and interfering elements make the interpretation of pasture copper levels very difficult.

Protein requirements are not usually expressed as percentage of crude protein in the diet, but from the U.S. National Research Council recommendations it is apparent that levels of crude protein below 10 per cent are likely to limit production in lactating ewes and this is in accord with the more recent observations of Whiting and Slen (1950). For dry sheep the level can no doubt be somwhat lower.

It is not proposed in this paper to use the above figures rigidly. It is appreciated that they must vary with the level of energy intake, the levels of growth and production of the sheep and the nature of the feed. The figures are given and will be used merely as a basis on which to discuss whether the nutrient levels in our New Zealand pastures are likely to be satisfactory or too low. The final decision cannot be made until experiments are conducted with the sheep themselves.

Experimental Technique and Methods

Pasture samples were plucked by hand in a manner as far as possible simulating the grazing action of sheep. Before drying, the samples were picked over by hand to remove any soil particles, roots, extraneous plants and any gross amounts of dead stalk.

Botanical species were then identified and classified in order of dominance. Throughout this text the common or local name for each species is used, but the corresponding botanical names are listed in an appendix.

Chemical analysis of the dried ground materials divided into ether extract, crude fibre, crude protein, ash, calcium, phosphorus and copper was conducted on each sample. Copper was estimated by the method of Clare, Cunningham and Perrin (1945).

Digestibility was determined as the mean value obtained from three sheep fed in digestibility crates.

Experimental Results

I. *Survey of Some South Island Hill Pastures*

Pasture samples were collected from 19 different localities of which Nos. 1–4 could be classified as high country tussock grassland, Nos. 5–11 as hill country tussock grassland, Nos. 12–16 as hill country out of bush and Nos. 17–19 as plainsland (see Tables I and II). The summer sample was collected in January-February 1950 at which stage many of the samples were fairly mature, containing dry stalk and seed with some leaf. The spring sample was collected in the following season, that is, in October-November 1950, and these samples were generally green and leafy though a number were not obtained until there was some development of stalk.

The main species in the samples from each locality together with a general classification of stage of growth of the material as a whole are listed in Table I. The contribution of the different species varied somewhat from spring to summer, but this was not considered of sufficient importance to complicate the simplified Table. Clovers were present in very small amounts in a few of the samples.

The chemical composition of the samples is given in Table II. For the sake of brevity, crude protein, crude fibre, calcium, phosphorus and copper only are listed. Ether extract was invariably below 3 per cent, while ash varied from 5.5 to 14.1 per cent with the majority between 8 and 11 per cent.

It will be seen from Table II that by the usual standards of pasture composition the samples analysed were of unusually low nutritive value. As might be expected, the spring samples were superior to the summer ones in all respects, and the high country ones were the lowest of all. The following points arise from Table II:

(i) *Protein*: The mean level of 13.8 per cent crude protein in the spring samples can be considered satisfactory, but the drop to 7.9 per cent in summer must bring the level to a state bordering on deficiency.

(ii) *Calcium*: The calcium status can be considered relatively satisfactory.

(iii) *Phosphorus*: The phosphorus status is very low and especially in the summer is well below that deemed necessary to meet the requirements even of dry sheep.

(iv) *Copper*: In view of the uncertainty as to copper requirements it is not possible to classify the samples accurately. The mean summer level of 4.1 p.p.m. is certainly low, and some samples are even down to 3.0 p.p.m.

TABLE I. PASTURE SPECIES AND STAGE OF GROWTH OF SAMPLES COLLECTED FROM DIFFERENT LOCALITIES

Location	Dominant Species						Stage of growth a-spring b-summer			
	Blue tussock	Danthonia	Sweet vernal	Browntop	Fog	Cocksfoot	Leafy	Leaf & stalk	Stalky	Mature, seeding
1. Cass	x		x	x			a			b
2. Lake Lyndon	x		x	x					b	
3. Hanmer		x	x	x				a	b	
4. Grampians			x	x				a		b
5. Culverden		x	x				a		b	
6. Weka Pass		x	x				a			b
7. Ashley Gorge			x		x	x	a	b		
8. Glenroy			x	x			a	b		
9. Mt. Hutt			x		x	x	a	b		
10. Hakataramea		x					a			
11. Bank's Peninsula (loess)		x				x	a			
12. Tapawera			x	x				a		b
13. Langley Dale		x		x			a			
14. Bank's Pen. (volcanic)						x	a	b		
15. Tuatapere			x	x	x		a	b		
16. Nightcaps			x		x			a		
17. Burnham			x	x			a			b
18. Lincoln			x		x		a		b	
19. Lumsden				x				a		

TABLE II. CHEMICAL COMPOSITION OF PASTURES
(expressed as percentage on dry matter)

Location	Season	Protein (%)	Fibre (%)	Calcium (%)	Phosphorus (%)	Copper (p.p.m.)
1. Cass	Spring	6.5	30.7	0.30	0.13	3.6
	Summer	5.4	30.4	0.30	0.12	3.0
2. Lake Lyndon	Summer	5.7	28.7	0.24	0.10	3.2
3. Hanmer	Spring	10.6	27.8	0.36	0.20	5.5
	Summer	8.3	27.4	0.33	0.14	4.6
4. Grampians	Spring	10.5	23.2	0.38	0.19	5.4
	Summer	4.6	31.4	0.34	0.12	3.6
5. Culverden	Spring	15.8	24.7	0.43	0.33	7.3
	Summer	7.0	29.9	0.31	0.13	5.2
6. Weka Pass	Spring	16.1	25.2	0.66	0.24	5.6
	Summer	7.1	29.8	0.27	0.10	3.2
7. Ashley Gorge	Spring	14.2	22.4	0.35	0.34	5.3
	Summer	6.2	29.4	0.34	0.15	3.0
8. Glenroy	Spring	12.6	22.4	0.40	0.16	5.6
	Summer	7.6	27.3	0.25	0.09	5.5
9. Mt. Hutt	Spring	18.7	19.2	0.54	0.31	5.8
	Summer	8.0	28.6	0.42	0.17	4.2
10. Makaroroa	Spring	14.6	24.5	0.59	0.30	8.3
11. Bank's Peninsula	Spring	19.3	20.9	0.35	0.30	8.8
12. Tapawera	Spring	10.5	27.0	0.33	0.11	5.6
	Summer	7.4	30.0	0.23	0.09	3.6
13. Langley Dale	Spring	12.7	24.2	0.38	0.23	7.1
14. Bank's Peninsula	Spring	25.3	17.0	0.54	0.47	10.7
	Summer	16.3	26.7	0.38	0.33	7.7
15. Tuatapere	Spring	13.2	22.0	0.43	0.21	7.4
	Summer	10.8	24.5	0.27	0.13	5.4
16. Nightcaps	Spring	11.4	26.1	0.34	0.21	5.6
17. Burnham	Spring	18.8	18.0	0.34	0.24	6.8
	Summer	8.2	27.3	0.20	0.10	4.4
18. Lincoln	Spring	19.3	17.2	0.61	0.19	6.7
	Summer	9.0	27.6	0.33	0.06	4.8
19. Lumsden	Spring	9.3	23.1	0.53	0.27	6.2
Mean of all localities (except No. 14)*	Spring	13.8		0.44	0.23	6.3
	Summer	7.9		0.29	0.12	4.1

*See Page 518

Digestibility of High Country Pasture: Digestibility trials were conducted on mixed pasture obtained from a large shingle fan at Cass. Material was obtained in spring, summer and winter. The botanical composition was much the same in each case and was approximately: blue tussock, 40 per cent; browntop, sweet vernal and fog, 50 per cent; other species, 10 per cent. The sheep consumed nearly 400 g. dry matter of this material per day. The summer material was dry and mature, the sweet vernal was seeding and the sample had the appearance of hay. The winter material was worse, consisting of some bottom leaf but a preponderance of dry or dead stalk. The spring sample was rather better, in that there was more green bottom growth, but there was still much stalk from the previous season.

Table III summarises the composition, digestibility and nutritive value of the three sets of pasture.

TABLE III. DIGESTIBILITY COEFFICIENTS OF SPRING, SUMMER AND WINTER HERBAGE

	Spring		Summer		Winter	
	Comp. (%)	Dig.Coeff.	Comp. (%)	Dig.Coeff.	Comp. (%)	Dig.Coeff.
Ether Extract	1.9	18.7	2.0	24.3	1.9	15.2
Crude Protein	6.5	33.5	5.5	21.2	4.6	12.1
Crude Fibre	30.7	54.6	30.4	55.4	30.0	52.9
N-free Extractive	53.2	43.6	55.5	47.7	55.6	44.1
Ash	7.7		6.6		7.9	
Starch equivalent		26.6		23.7		25.6
Total Dig. Nutrients		42.9		39.9		41.5
Dig. Crude protein		2.2		1.2		0.6
Nutritive Ratio		18.5		33		73

These digestibility trials show the nutritive value of the material to be very low indeed, equivalent only to poor roughage. It must be remembered, however, that the material collected for the trials was somewhat more fibrous and lower in protein than the average high country pasture (c.f. Table II). Also, in diets of such low protein content the metabolic faecal nitrogen makes the apparent digestibility of protein lower than the true digestibility.

TABLE IV. CHEMICAL COMPOSITION OF INDIVIDUAL SPECIES FROM CASS
(expressed as percentage on a dry-matter basis)

Species	Season	Crude Protein (%)	Ether Extract (%)	Crude Fibre (%)	Ash (%)	Calcium (%)	Phosphorus (%)	Copper (p.p.m.)
Fescue Tussock	Spring	8.8	1.21	34.1	7.9	.12	.03	2.9
	Summer	5.4	1.93	33.0	8.6	.11	.05	2.0
	Winter	3.4	1.65	34.9	7.0	.13	.04	2.6
Blue Tussock	Spring	5.4	2.28	30.2	7.2	.12	.06	2.7
	Summer	7.0	2.60	29.9	7.7	.17	.08	2.9
	Winter	5.1	2.30	29.8	8.6	.19	.06	2.6
Browntop	Spring	13.6	2.40	21.4	9.0	.38	.19	5.1
	Summer	7.0	1.56	28.2	7.7	.20	.11	3.4
	Winter	3.3	1.12	25.0	6.5	.20	.04	2.3
Sweet Vernal	Spring	11.3	2.49	29.1	6.8	.31	.19	4.8
	Summer	8.4	1.88	28.0	7.1	.34	.11	2.3
Yorkshire Fog	Spring	12.5	4.71	16.4	11.9	.57	.22	5.7
	Summer	8.4	1.87	28.9	8.8	.24	.09	2.8
	Winter	7.5	2.38	26.0	12.4	.47	.11	6.2
White Clover	Spring	19.7	3.00	15.4	10.4	1.48	.21	7.3
	Summer	14.8	2.20	20.3	7.5	1.22	.16	6.8
	Winter	20.8	4.65	16.0	10.0	1.69	.26	8.1
Catsear	Spring	15.8	5.68	11.0	14.5	1.74	.22	7.4
	Summer	9.7	4.18	19.2	10.6	1.41	.15	5.9
	Winter	18.3	5.67	11.9	16.5	2.59	.20	10.1

II. *Chemical Composition of Individual Species*

Analyses were made of the different species collected from one site at Cass. The site was a north-westerly face at an altitude of 3000 ft and on the Kaikoura series soil type. Annual rainfall is 50-60 in. The samples were taken in November, February and June, 1950 to give the spring, summer, winter samples, though the spring one belonged to a different growing season from the other two.

The most common species found in this area were fescue tussock, blue tussock, browntop, sweet vernal, Yorkshire fog, white clover and catsear. The chemical composition of these species is given in Table IV.

The following observations may be made from these figures:

(i) The two tussocks are of exceptionally low nutritive value, being deficient at all times in protein and minerals. It is of interest to note, however, that the blue tussock is better than fescue tussock. This is in keeping with the observation that stock will eat the former but very seldom eat the fescue tussock. Another point is that the protein level is higher in summer than in spring, due probably to the late growing period of tussocks.

(ii) The three grasses—browntop, sweet vernal and fog—are similar in composition. The protein and phosphorus levels in both summer and winter are very low indeed.

(iii) White clover and catsear are similar in chemical composition, being high in protein, low in fibre, exceptionally high in calcium, borderline for phosphorus, and quite good for copper. It is clear that these two species stand in a class apart from all others.

III. *Chemical Composition of Individual Species Throughout the Growing Season*

The next series of analyses was made on individual species sampled at intervals throughout the 1951-52 growing season. The site chosen was a 2½-acre, rabbit-proof enclosure of the North Canterbury Catchment Board above Lake Georgina near Lake Coleridge. The enclosure was on a fairly steep slope, facing north, at an altitude of about 2,000 ft, and on Omarama-series soil type. At no time during the period was the enclosure grazed, nor had any lime or superphosphate ever been applied. Mean annual rainfall is approximately 40 in.

Samples were obtained on 17 October, 21 November, 19 December 1951, and 23 January and 1 April 1952. This covered the growing period of most of the species from early spring to seeding. Not all

species were collected every time; some were taken on only one or two occasions. The species analysed were: fescue tussock, blue tussock, sweet vernal, danthonia, Yorkshire fog, plume grass, blue wheat grass, suckling clover, catsear, hawkbit, sorrel and carmichaelia. The stage of growth of each species was classified into: (i) leafy—before appearance of stalk; (ii) stalk—leafy with stalks not yet flowering; (iii) flower—in flower; (iv) seed—seed ripening or ripe; (v) seeded—seed shed, sample usually dry leaf and stalk; (vi) bottom growth—autumn growth at the bottom of dry leaf and stalk. Some species were not sampled in the initial stage owing to the small amounts present (sorrel, suckling clover) or to the fact that they did not emerge from cover of tussock and matagouri until the later stages of growth (blue wheat grass, plume grass). In certain cases the samples were separated into leaf and stem, and the two analysed separately. By weighing each after drying, the composition of the whole sample could be calculated. Tussocks were sampled by cutting them at half their height above the ground; plume grass and blue wheat grass, which grew only from the shelter of tussock and matagouri, by plucking only the accessible portions; suckling clover, which has a creeping habit, by plucking the whole plant at just above ground level; carmichaelia by clipping the tips about a quarter-inch in length. All the species except fog and carmichaelia grew within the enclosure. The fog was found in a more gentle slope below the enclosure and although the soil type was similar it was considerably moister. Carmichaelia was found one mile away on a dry-river terrace. Browntop was not present in or near the enclosure. The main analytical data are given in Table V.

The following observations can be made from these figures:—

(i) *Tussocks*: The tussocks are deficient in protein, phosphorus and possibly copper at all times. Blue tussock is considerably better than fescue tussock in protein and is rather less fibrous. It also comes into flower and seed earlier.

(ii) *Grasses*: The grasses—sweet vernal, danthonia, fog, plume grass and blue wheat grass—when at the same stage of growth have a somewhat similar chemical composition. Fog appears to be slightly better than the others, due possibly to the particular samples being favoured by a moister soil. Danthonia in the early stages appears to be the poorest, and this may be due to the higher proportion of dead leaf which seems always to be associated with danthonia. Taking the grasses as a whole, the period when the protein content is greater than 10 per cent is limited to the very short period in the early leafy stage of growth. For the greater part of the growing season the protein content is of the order 6—8 per cent.

(iii) Suckling clover and catsear are much superior to the grasses.

TABLE V. CHEMICAL COMPOSITION OF INDIVIDUAL SPECIES FROM LAKE COLERIDGE
(expressed as percentage on dry-matter basis)

Species	Month	Stage of Growth	Protein (%)	Fibre (%)	Ca (%)	P (%)	Cu (p.p.m.)
Fescue Tussock	Oct.		4.5	35.2	0.30	0.12	
	Nov.	Leaf	5.2				
	Dec.	Stalk	5.6	37.5			2.2
	Jan.	Flower-seed	4.4		0.16	0.14	
	Apr.		4.3				
Blue Tussock	Oct.	Leaf	7.3	25.9	0.34	0.09	
	Nov.	Stalk	6.3				
	Dec.	Flower	7.9	34.2			3.7
	Jan.	Seed	5.8		0.19	0.15	
	Apr.		6.3				
Sweet Vernal	Oct.	Leaf-stalk	10.7	24.7	0.58	0.24	5.3
	Nov.	Flower	7.8	29.5	0.30	0.20	3.7
	Dec.	Seed	6.5	27.7	0.25	0.18	-
	Jan.	Seeded	5.5	30.0	0.24	0.17	3.4
	Apr.	Bottom growth	5.2	30.4	0.28	0.10	-
	Nov.	Leaf	8.5	26.0	0.41	0.20	3.3
		Stem	7.5	30.1	0.25	0.20	3.9
	Jan.	Leaf	7.3	26.1	0.33	0.20	3.7
		Stem	4.5	32.7	0.20	0.16	3.2
	Apr.	Leaf	8.5	23.4	0.36	0.13	3.2
		Stem	3.8	33.7	0.23	0.09	-
Danthonia	Oct.	Leafy	9.8	27.4	0.37	0.21	-
	Nov.	Leafy	9.1	28.1	0.33	0.24	3.2
	Dec.	Flower	7.4	31.3	0.26	0.20	-
	Jan.	Seed	6.4	31.7	0.24	0.19	3.5
	Apr.	Seeded	4.7	32.7	0.28	0.12	-
	Jan.	Leaf	7.0	30.3	0.32	0.20	3.2
		Stem	6.0	32.7	0.19	0.19	3.7
Yorkshire fog	Nov.	Leafy	16.7	23.2	0.52	0.34	4.9
	Dec.	Leaf-stalk	11.3	26.4	0.34	0.32	-
	Jan.	Flower	6.8	30.0	0.30	0.25	4.3
	Apr.	Bottom growth	7.0	29.0	0.40	0.19	-
	Jan.	Leaf	8.2	27.6	0.45	0.28	-
		Stem	6.1	31.2	0.23	0.24	-
	Apr.	Leaf	7.8	25.2	0.50	0.23	3.8
		Stem	6.0	34.9	0.29	0.14	-
Plume Grass	Dec.	Stalk	8.6	32.5	0.23	0.26	2.7
	Jan.	Flower	6.0	33.3	0.20	0.27	-
	Apr.	Seeded	3.7	34.6	0.23	0.14	-
	Jan.	Leaf	6.3	32.3	0.31	0.30	-
		Stem	6.0	33.5	0.17	0.26	-
Agropyron	Jan.	Seed	5.8	33.0	0.25	0.22	-
	Apr.	Seeded	5.1	34.0	0.30	0.17	-
Sorrel	Nov.	Flower	9.0	19.9	0.47	0.25	3.6
	Apr.	Seeded	7.8	-	1.06	0.13	-
Carmichaelia	Nov.		8.9	35.6	0.52	0.08	3.3
	Apr.		3.2	-	0.75	0.09	-
Catsear	Oct.	Leaf	14.2	-	1.36	0.49	-
	Nov.	Leaf	11.3	12.5	1.49	0.37	5.4
	Dec.	Stalk	10.5	14.7	1.37	0.47	5.6
	Jan.	Flower	8.7	22.0	1.05	0.40	5.6
	Apr.	Seeded	6.8	29.0	1.27	0.28	4.8
	Jan.	Leaf	8.8	-	1.41	0.48	5.4
		Stem	8.7	25.0	0.90	0.35	5.6
Hawkbit	Jan.	Flower	9.3	20.0	1.44	0.36	6.2
Suckling Clover	Dec.	Flower	13.6	22.6	0.92	0.27	4.5
	Jan.	Flower-seed	11.7	27.7	0.92	0.26	6.6
	Apr.	Seed	13.4	-	0.75	0.22	-

Discussion

Tussocks

The fescue tussock is generally considered to be unpalatable and therefore to provide little feed for stock. Under certain conditions stock may eat the tops and the seed-head but little else. The young growth which comes away from fescue tussock after a burn is, however, readily eaten. In this work no analysis of regrowth after burning was made. Under existing Catchment Board policy, very little burning is being done in the high country, so that the regrowth after burning is unimportant as a contributor to the diet of sheep and cattle.

The blue tussock is definitely more palatable than the fescue tussock. While some runholders claim that it is not eaten, others, and probably the majority, claim that it is. Chemical analysis shows it to be higher in protein (up to a maximum of 7–8 per cent) and lower in fibre than fescue tussock, and that it is not without some value as a feed for stock. As far as mineral content is concerned, both species of tussock are low in calcium, deficient in phosphorus (especially at Cass), and low or deficient in copper. It is probable that stock eating only the seed-heads of the tussocks obtain material of higher value than that analysed.

Grasses

The grasses of the high country follow the same trends as those of the low country in respect to the relationship between stage of growth and chemical composition. In the leafy stage of spring growth crude protein is of the order 10–15 per cent. This declines rapidly with advancing maturity to a level of approximately 6–7 per cent in the seeding stage at midsummer. After this the level during autumn and winter is dependent on the amount of bottom growth produced during the autumn but the levels do not seem to rise significantly above the midsummer value. Crude fibre follows the recognised inverse relationship to crude protein. Calcium is highest in spring and lowest in summer, rising slightly in autumn. The levels of calcium are above the minimal requirements for stock at all times of the year except in midsummer. The low midsummer values are probably not important in practice owing to the considerably higher levels in other seasons. Phosphorus is also highest in spring and is low for the remainder of the year. Spring levels are of the order of 0.20–0.24 per cent, falling to 0.10–0.20 per cent in midsummer and winter. With some exceptions, the phosphorus levels are below the recommended requirements of ewes at practically all times of the year. Copper levels are all low, being in the region of 3–5 p.p.m.

As far as can be judged from the limited data available, all the different species of grasses—browntop, sweet vernal, danthonia, fog, plume grass and blue wheat grass—conform to the general pattern of seasonal change and have similar chemical compositions at the same stage of growth. The only significant divergence from this statement is in respect to Yorkshire fog which was superior to the other grasses at Lake Coleridge but not at Cass. This, as

previously stated, may have been caused by the fog having been collected from a moister and possibly higher fertility soil than that in the enclosure where all the other grasses were taken.

As it is possible, indeed probable, that stock are selective grazers on the high country and able to avoid eating at least some of the stalky material, several samples of the grasses were divided into leaf and stem which were analysed separately. This showed that leaf was superior to stem in regard to all constituents and especially in calcium. However, the superiority of leaf over stem in the important constituents, protein and phosphorus, was not as great as expected, and insufficient to raise the general status from apparent deficiency to sufficiency. For instance, the protein level of the leaves of the grass species during the summer and autumn months was approximately 8.0 per cent.

Clovers

The clovers are much superior to the grasses in chemical composition. At Cass the approximate levels in white clover were: protein, 15–20 per cent; calcium, 1.2–1.7 per cent; phosphorus, 0.16–0.26 per cent; and copper, 6–8 p.p.m. At Lake Coleridge, suckling clover was collected only at the maturer stages of growth, since there was insufficient quantity available at the earlier stages to give a reasonably representative sample. Nevertheless, its protein content was at all times above 10 per cent, calcium, 0.75–0.90 per cent, phosphorus, 0.11–0.27 per cent, and copper, 5–7 p.p.m.

The clovers, if present in sufficient quantity, would undoubtedly improve the diet of the stock, but under normal circumstances they are present to such a small extent that they make only a small contribution to the total diet.

Catsear

This flatweed is fairly common in the tussock grasslands and is recognised by runholders as a valuable plant for stock. Chemical analysis shows it to be superior to the grasses and comparable with the clovers. The approximate percentages of the chemical constituents are: protein, 10–15; fibre, 10–20; calcium, 1.0–2.0; phosphorus, 0.30–0.50: at Lake Coleridge, but 0.15–0.22 at Cass; copper, 5–6 p.p.m. at Lake Coleridge and 6–10 p.p.m. at Cass. From the single analysis of the related species, hawkbit, it is probable that this flatweed is similar to catsear. As catsear is very palatable it can, if present in sufficient amounts, make a useful contribution to the diet.

Other species

Sorrel has no outstanding features in its chemical analysis except perhaps that it is fairly high in calcium which is already present in sufficient quantities in the grasses. In carmichaelia, which is a low woody plant eaten by stock, protein is low, fibre is high, calcium is high and phosphorus very low. It cannot therefore be looked upon as a very useful contributor to the diet.

Pastures

The chemical composition of the mixed pasture samples (Table II) from the different localities in the South Island may now be considered. In these samples the grasses sweet vernal, browntop and danthonia predominated and since these have been shown to have similar compositions at equivalent stages of growth, any differences between samples would most likely be due to soil type and stage of growth.

The Bank's Peninsula samples were outstanding in this series. Although admittedly they were leafier than other samples, their protein, phosphorus and copper levels were much higher. The sample off the volcanic soil is significantly better than that off the loess covered soil. This is a reflection of the high fertility volcanic soil of this locality and must also be related to the fact that the locality is the only one in the series capable of dairy and fat-lamb production. On the other hand, the four high-country samples appear to have on chemical analysis the lowest nutritive value. Taking all the samples upon which store sheep are produced, i.e. excluding Bank's Peninsula, it is evident that the levels of protein, phosphorus and copper are very low. While they may be satisfactory in early spring they are definitely very inferior in summer and presumably for as long thereafter as the feed is predominantly roughage. Thus, the area upon which low nutritive levels occur is not merely the high country tussock grassland but must be widened to include the great majority of our hill country where store sheep only can be produced.

It is evident from the figures quoted that there is an apparent deficiency of protein and phosphorus for breeding stock on much of our high country and hill country for quite considerable periods of the year. Whether there is a true deficiency has yet to be proved because analytical figures alone prove very little. Until grazing and feeding trials designed to test these points are conducted the issue must remain in doubt. If there are deficiencies they are not very pronounced, since sheep and cattle do live and breed in the regions concerned, even if their production and rate of reproduction are not high. But it could well be that the levels of protein and phosphorus are low enough to limit productive capacity at certain times of the year without causing recognisable symptoms of deficiency.

Two factors of importance limit the usefulness of analytical figures as the sole index of sufficiency or deficiency. Firstly, there is a lack of knowledge of the actual requirements of sheep for energy, protein and minerals under the particular environmental conditions involved. Requirements are known to vary with the type (growth, reproduction, lactation, wool) and rate of production, so animals may be able to survive on considerably less than the recommended allowances by adapting their production to their food intake. Secondly, there is the complication caused by selective grazing. It is almost certain that the diet of the animal is better than that indicated by the analyses, since the animal does exert selection, and such selection would probably be in favour of the more highly nutritious material available. Clearly selective grazing of clovers and catsear can raise the level of an other-

wise all-grass diet, and possibly grazing of seedheads can do likewise. There may also be other species not included in this study that have some special value. A notable feature of the analyses is, however, that in the mature stages of growth, even the leaves on their own are of low value so that eating leaf in preference to stem will improve the diet, but not very greatly.

The grazing management of this country does not favour the production of feed of high nutritive value. Under the prevalent system of set stocking, apart from the summer-country—winter-country change, and of low stocking rate per acre, there is little check to the rapid maturing of the pasture plants in the short growing season, with the consequent rapid decline in food value. This is followed by long summer, autumn and winter periods when the feed is very stalky, containing much dead leaf and little actively green leaf. Until one actually collects samples, it is difficult to appreciate how much dead material is inseparably mixed with the current season's growth. This is, no doubt, one of the reasons for the low nutritive value even of spring samples. The period when roughage forms the bulk of the diet is very long under these conditions. It would be of some assistance if the pasture could be made to include both early and late maturing species so that there is a greater spread of pasture growth and a longer period when succulent material is available. But fundamentally, the grazing management of this low carrying capacity country renders it impossible to obtain efficient utilisation of pasture growth. Until it becomes economically possible to subdivide and carry out some form of grazing control this problem cannot be solved.

This preliminary study has merely shown that the nutritive value of the high country and hill country pastures is very low and that this is particularly so for protein and phosphorus. It has indicated that the subject is one worthy of further study, particularly along more practical lines such as in the grazing habits of sheep, grazing management, top-dressing and supplementary feeding.

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APPENDIX

(List of Common and Botanical Names of Species)

Blue tussock	*Poa colensoi*
Blue wheat grass	*Agropyron scabrum*
Browntop	*Agrostis tenuis*
Carmichaelia	*Carmichaelia monroi*
Catsear	*Hypochaeris radicata*
Danthonia	*Danthonia pilosa*
Fescue tussock	*Festuca novae-zealandiae*
Fog	*Holcus lanatus*
Hawkbit	*Leontodin hispidus*
Matagouri	*Discaria toumatou*
Plume grass	*Dicheliachne crinata*
Sorrel	*Rumex acetosa*
Sweet Vernal	*Anthoxanthum odoratum*
Suckling clover	*Trifolium dubium*
White clover	*Trifolium repens*

"CLOUD" OR VASCULAR BROWNING IN TOMATOES

I. CONDITIONS AFFECTING THE INCIDENCE OF "CLOUD"

By E. B. KIDSON* and D. J. STANTON, Cawthron Institute, Nelson

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Summary

Cloud in glasshouse fruit has been increased by soil sterilization, heavy watering, raw organic manures, glucose, heavy defoliation and the opposite extreme, excess leaf growth. It has been decreased by light watering, by very heavy dressings of potash during the winter and by the frequent application of nitrogenous fertilizers, muriate of potash or calcium chloride throughout the season. These beneficial treatments tended to produce a thinner-stemmed, less rank type of growth and a slightly reduced weight of fruit per plant.

INTRODUCTION

"Cloud" is the local name for a form of abnormal ripening of the fruit, which causes serious losses in the unheated tomato houses of the Nelson district. The disorder resembles that described by Bewley and White[1] in England as a form of "blotchy ripening" and by Conover[2] in Florida as "vascular browning." The cause of the abnormality does not appear to have been identified. Work prior to 1947 by officers of the Cawthron Institute[3] showed that cloud was worse on steamed than on unsterilized soil and was increased by heavy watering. It was found to occur on fresh as well as on old glasshouse soils. Areas of the glasshouse not receiving the full amount of sun showed increased cloud. Plants grown in tins placed on the surface of the soil were seldom affected. Investigations at that time failed to reveal a pathogen as a cause of the disorder. The possibility of a virus was not eliminated, but the ease with which cloud is influenced by glasshouse management and fertilizer treatment makes this explanation unlikely. The work of Stoner and Hogan[4] in the U.S.A. on what appears to be the same disorder supports this opinion.

Investigations at the Cawthron Institute over the past five years suggest that cloud is a physiological disorder which can be reduced or eliminated by certain soil treatments and increased by others, and that cloud fruit has certain chemical characteristics. An account of these observations is given in this series of papers.

DESCRIPTION OF THE DISORDER

Fruit

Tomatoes affected by cloud ripen unevenly. Areas of green or brownish-green stand out against the red of the ripening fruit. These patches may finally become a yellowish-red, or even attain superficially a normal red colour. Cutting below the surface reveals brown veins in the abnormal areas. The necrosis affects the vascular system and surrounding parenchyma cells. The damage is usually confined to the outer walls and is seldom found in the centre or radial walls. Unlike hard core[5], which is always present at the stem-end, cloud may

* Officer of the New Zealand Department of Scientific and Industrial Research.

appear anywhere on the fruit. Several patches may be present on the same fruit. The affected areas may vary in size from a small spot to the entire surface of the tomato. The necrosis appears to develop as the fruit approaches maturity and has been found not earlier than about eight weeks from the time of setting. The flavour of affected fruit is poor.

Observations have suggested that certain other disorders are allied to cloud and induced by similar conditions. The disorder is frequently associated with corkiness of the fruit and hollowness, accompanied by incomplete seed development. "Corky" fruit has a light-coloured layer, dry in appearance, associated with the vascular tissue. This defect may affect the core of the fruit as well as the peripheral wall. Under the microscope the corky tissue appears to consist of cells partly or wholly separated from one another by gaseous pockets. Hollow fruit is particularly prevalent where cloud is bad. The fruit is of abnormal shape with flattened surfaces. Cloud, hollowness and cork are shown in Figs. 1–3.

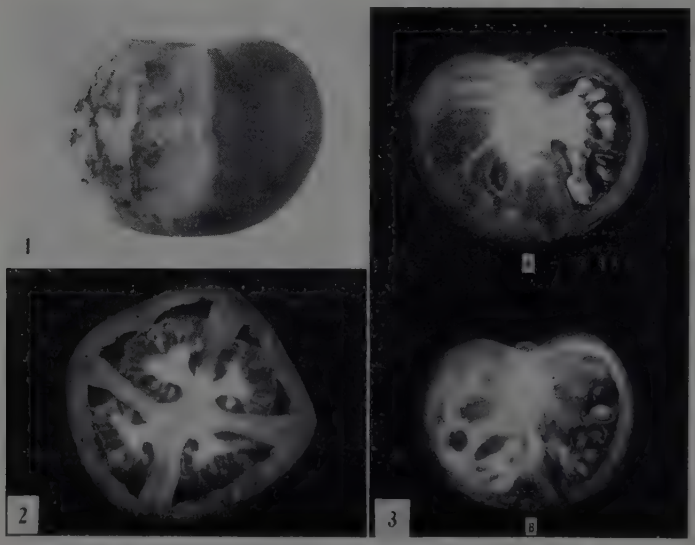

Fig. 1.—"Cloud" with skin removed to show necrosis.
Fig. 2.—Fruit showing hollowness, "cloud" and poor seed development.
Fig. 3.—Cork, A. Healthy fruit. B. Corky fruit.

These disorders are most severe in the fruit of the lower bunches, but can persist more or less throughout the season. Cloud frequently decreases to a negligible amount during midsummer, increasing again to some extent in late February and March.

Plant

Though it has not always been possible to correlate a definite growth habit with cloud, it has been found that coarse, rapidly-growing, heavy-

cropping plants are very susceptible. Such plants tend to be thick in the stem, have large leaves showing little tendency to wilt in the hot weather and carry big trusses of large and irregularly shaped fruit.

Occurrence

In the Nelson district, glasshouse fruit in unheated houses is particularly susceptible to the disorder. The plants are set out in August (early spring) and the crop is in production by the end of November. The greatest losses occur in the December fruit. In heated houses cloud is frequently present but appears to be a less serious problem. The disorder is not limited to glasshouse tomatoes. In a wet season it can affect outdoor fruit to some extent, particularly where the soil has been sterilized.

Cloud has been found on several different soil types and on soils with a range of pH values.

EXPERIMENTAL PROCEDURE

Soil Type

The experiments were carried out in unheated houses located on a clay loam with underlying gravel at a depth of 5 ft. Ground-water is not present within 10 ft of the surface. The soil has a high calcium and magnesium content and a pH of approximately 7. Exchangeable calcium and magnesium figures of 20 m.e. and 7 m.e. respectively per 100 g. of soil are typical. The exchangeable potash, built up from previous fertilizer applications, varies from 1 to 3 m.e. but, except for special potash plots, is reasonably constant throughout any one house. Total nitrogen falls between 0.20 and 0.25 per cent.

Climate

The climate is comparatively mild with an average of about 2,500 hours of sunshine and 100 to 130 rainy days for the year. The mean daily temperatures per month in the screen range from 55° to 72° F. (maximum) and 37° to 55° F. (minimum). Summer temperatures seldom exceed 80° F. and frosts of more than 7° F. are rare. About 50 to 70 frosts are usual for the year, nearly all in the May-August period.

Soil Treatment

For these experiments steam sterilization of the soil by the harrow method was carried out during the winter on all plots except where specified. Where chloropicrin was used it was applied with a soil injector at the rate of 3 c.c. per sq. ft. Sterilization was followed by flooding with several inches of water.

Fertilizer Treatment

The standard fertilizer was as follows:

Base dressing per sq. yd.:
- 4 oz. superphosphate
- 2 oz. muriate of potash

} broadcast before digging.

Topdressings (1) and (2):
- 8 parts superphosphate
- 4 parts muriate of potash
- 3 parts dried blood
- 3 parts sulphate of ammonia

} applied at a total rate of 9 oz. per sq. yd. between the time of planting and December.

Topdressing (3):

The same proportions as above except that nitrate of soda replaced sulphate of ammonia. Applied at the rate of 4½ oz. per sq. yd. in December.

The quantities of N, P and K supplied by the standard treatment remained approximately the same throughout, though certain variations were sometimes introduced in the time of applications and the proportions of nitrate to ammonium salt. These minor modifications appeared to have little or no effect on cloud.

Experimental plots with a variety of treatments mostly superimposed on this standard fertilizer have been examined for the incidence of cloud and associated disorders.

Plots

Plots varied in size from 24 to 52 plants except for one experiment where the number is specified. The spacing was 13 in. between plants and 2 ft. 6 in. between rows. The houses were planted in the third week of August and the crop usually began to ripen towards the end of November. Picking was continued till March. In November, a mulch of about 5 tons per acre of clover straw was laid down and this was dug into the soil at the end of the season. The plants, variety Potentate, were not topped.

Results

Occurrence of Cloud throughout the Season

Observations have confirmed previous ones that cloud is usually worst in the early pickings and that it decreases and frequently disappears during mid-season, to rise again in late February and March. This is illustrated by data for two plots given in Table I. The first picking was on 3 December.

Table I. Occurrence of Cloud throughout the Season 1951/52
(Results expressed as number of affected fruits per pound harvested)

Dates of Picking	B 8	B 12
3/12/51 to 17/12/51	1.56	0.35
18/12/51 to 2/1/52	1.37	0.36
3/1/52 to 21/1/52	0.58	Nil
22/1/52 to 4/2/52	0.11	0.01
5/2/52 to 25/2/52	0.80	0.30
26/2/52 to 17/3/52	0.95	0.50

In comparing the amount present early and late in the season (Table I) the fact that fruit tends to be smaller in the late pickings should be taken into account.

Soil Treatments and Other Factors Affecting the Incidence of Cloud

Soil Sterilization

It has been found over many seasons that soil sterilization by steaming produces a much increased growth and yield. Recent work has confirmed earlier experiments which indicated that steaming produces at the same time an increased susceptibility to cloud. In Table II are given figures for adjacent steamed and unsteamed plots for the season 1950/51. In this table and all subsequent tables except where specified, yield is expressed as pounds per plant and cloud as number of affected fruits per 10 plants.

TABLE II. EFFECT OF SOIL STERILIZATION ON THE INCIDENCE OF CLOUD

Treatment	1950-51		1951-52	
	Cloud	Yield	Cloud	Yield
Unsterilized	0	4.1	0	3.3
Steamed	4.0	9.9	48.9	10.2

It has been found that fumigants such as chloropicrin behave like steam in producing increased susceptibility to cloud. Work during the last season, however, has indicated that cloud may be less severe than with steam. Thus, four plots, chemically sterilized for several seasons, averaged 9.7 lb of fruit per plant and 27 cloud fruits per 10 plants, in the 1951/52 season, while figures for four comparable plots were 9.7 lb and 62 cloud fruits.

Seasonal Effects

It has been found that under similar cultural conditions the amount of cloud has varied considerably from season to season. Thus, in the 1950/51 season, plants were relatively free from the disorder while in the 1951/52 season the incidence of cloud was very high. The latter was an exceptionally wet season with 56 days on which rain fell during the October-December period, compared with 27 in the same months in the 1950/51 season. The total hours of sunshine during this period were 675 and 775 respectively, though entirely sunless days were few in both seasons. Within the glasshouses, comparable air and soil temperatures for the two seasons have been as shown in Table III. The soil temperature was taken daily at 9 a.m. at a depth of 6 in. The temperatures are expressed in degrees Fahrenheit.

TABLE III. AIR AND SOIL TEMPERATURES IN UNHEATED GLASSHOUSES (°F.)

Month	1950			1951		
	Air		Soil	Air		Soil
	Max.	Min.		Max.	Min.	
October						
Range	63-95	41-57	60-66	61-89	38-60	58-62
Average	84	48	62	79	48	60
November						
Range	75-94	43-58	61-66	67-91	39-58	57-62
Average	86	50	64	83	50	60
December						
Range	76-91	47-60	64-66	73-89	40-58	59-64
Average	87	52	65	84	50	62

It will be seen that air and soil temperatures were lower in the spring and early summer of 1951 than in the same period of the previous season.

In 1950-51, four standard control plots averaged 6.3 cloud fruits per ten plants, with a range of 1.7 to 15.4, while in the following wet season they averaged 51.6 with a range of 40.2 to 63.7. The same seasonal effect is seen in Table II for sterilized plots in a different house. Here the two steamed plots averaged 4.0 cloud fruits per 10 plants in the 1950-51 season and 48.9 in the following season.

Watering

It has been customary to apply a measured amount of water as a standard treatment to all glasshouse plots. Experiments at the Cawthron Institute over a period of years showed that an increase in the quantity applied at each watering increased the amount of cloud in the fruit and that a decrease had the opposite effect. Recent work has confirmed the harmful effect of heavy watering. Certain plots were given nearly twice the standard amount of water. Until mid-December they were watered twice as often as the standard plots and later extra quantities were applied at the normal times of watering. During the main growing period, from planting till the first week in February, these heavily-watered plots received 48 gal per plant in the 1950/51 season and 43 gal per plant in 1951/52. Over the same period standard plots were given 29 gal and 27 gal per plant for the same seasons. The effect of the extra water has been to bring about a very marked increase in the number of cloud fruits, as will be seen from Table IV, where heavy watering plots are compared with adjacent standard plots. The figures are averages for two plots in each treatment.

Table IV. Effect of Heavy Watering on the Incidence of Cloud

Number of Waterings	1950-51		1951-52	
	Cloud	Yield (lb)	Cloud	Yield (lb)
Standard	9.2	9.9	60.4	11.2
Standard x 2	65.8	12.8	100.9	12.0

Organic Manures

Certain fresh organic manures applied to the soil before steaming in quantities from 10-20 tons of dry-matter per acre have been found to induce heavy growth and an increased susceptibility to cloud. This effect has been produced by clover straw and oat-chaff. Fruit grown on plots treated with oat-chaff was of very poor quality, with much cloud and hollowness. Well-rotted compost did not usually have a harmful effect on fruit quality.

Glucose

The application of glucose to the soil has been found to affect the incidence of cloud. Certain plots were treated with glucose during the 1949/50 and 1950/51 seasons. An aqueous solution of commercial glucose syrup (2 lb to the gallon) was applied along the rows at the rate of 8 oz of the commercial syrup per sq. yd. calculated on the whole area of the plot. This quantity was equivalent to approximately 2/3

pt of solution per plant. The treatment was given four times during the period mid-September to late November. The amount of extra water supplied in this way was small. The glucose treatment, however, produced an increase in growth similar to that caused by heavy watering, and a greatly increased susceptibility to cloud.

The data in Table V show the cloud-inducing effect typical of glucose treatment.

TABLE V. EFFECT OF GLUCOSE ON THE INCIDENCE OF CLOUD

Treatment	Cloud	Yield (lb)
Standard	7.5	10.7
Standard—glucose	64.2	12.4

Amount of Defoliation

It has been noticed that plants accidentally broken above the second or third bunches at a stage where no further laterals are produced may develop much cloud in the remaining fruit. Experiments have also shown that hard defoliation may increase the susceptibility to cloud. In one plot (A 25), the plants were topped after the second bunch, and a lateral taken up as the main stem. Many lower leaves were removed and the foliage was much less than normal throughout the season. The second plot (A 26) was given the normal pruning, i.e. one main stem was allowed to grow and laterals removed. A few leaves were taken off near the ground. In the third plot (A 27), all laterals except those below the bottom truss were allowed to grow and were shortened to just below their first flower truss. These plants had much additional foliage but carried fruit trusses only on the main stem. The number of trusses of developing fruit were therefore approximately the same for all three treatments. Each plot consisted of 18 plants. Figures for cloud and yield are given in Table VI.

TABLE VI. EFFECT OF HARD AND LIGHT PRUNING ON THE INCIDENCE OF CLOUD—SEASON 1950/51

Plot No.	Treatment	Cloud	Yield (lb)
A 25	Hard pruning and defoliation	16.7	7.8
A 26	Standard pruning and defoliation	6.1	9.0
A 27	Light pruning	23.9	10.1

It will be seen from Table VI that both heavy and light pruning were associated with an increase in cloud. In A 25 cloud was present early in the season, while in A 27 the disorder developed later.

Low Fertilizer Level

Early experiments indicated that sterilized plots without fertilizer over a period of years tended to have less cloud as the yield

diminished. A recent no-fertilizer trial showed a yield and amount of cloud comparable with the standards, though the fruit quality was not good. The omission of nitrogen from the standard fertilizer brought about an increase in cloud, particularly in the early part of the season.

Heavy Fertilizer Applications

Potash: Under certain conditions potash in excess of the amount supplied in the standard fertilizer has reduced the susceptibility of the plant to cloud. Plots were treated with winter dressings of extra potash at the rate of one ton per acre for nine seasons in succession. Both sulphate and muriate were tested. Shortly before the eighth winter dressing, the potash removable by leaching with normal ammonium acetate was found to have increased from 1 m.e. to 5 m.e. per 100 g. of soil. In the early stages of the experiment, the extra potash was without apparent effect on cloud. Some reduction in the amount of affected fruit appeared as time went on, but not enough to suggest that the disorder is directly associated with a shortage of potash.

Table VII compares the incidence of cloud on these potash plots and neighbouring standard plots. 1950/51 was the eighth year of the experiment. In the following season the standard plots also received an extra ton of potash (as KCl) per acre. The lower figures for cloud in the potash-treated plots may therefore be looked upon as an indication of a beneficial effect of residual potash from the previous eight dressings.

Table VII. Effect of Continued Winter Applications of Extra Potash on the Incidence of Cloud

Treatment	1950-51		1951-52	
	Cloud	Yield (lb)	Cloud	Yield (lb)
Standard	15.6	9.6	55.6	9.7
Standard	4.8	10.0	59.2	10.3
Extra K_2SO_4	5.6	9.3	38.5	9.5
Extra KCl	5.6	8.7	29.6	9.3

A single very heavy winter dressing of potash at the rate of 4 tons per acre dug into the 0-12 in. depth produced fruit free from all but traces of cloud. However, growth was much retarded in the arly stages and yields were reduced, particularly in the early pickings.

In the 1951/52 season which was a very bad one for cloud, extra potash applied during the early part of the growing season proved of some benefit. Topdressings of muriate of potash, each at the rate of 4 oz. per sq. yd. were used in early and late October. Cloud from potash plots averaged 31.3 fruits per 10 plants, and comparable standard plots averaged 60.4 fruits.

Extra potash was very effective in counteracting the increased tendency to cloud produced by glucose. Muriate of potash was applied in solution along the rows four times during the October-

December period. The total quantity used was equivalent to 16 oz. per sq. yd. calculated on the total area of the plot. The potash-glucose treatment resulted in an average of 3.5 cloud fruits per 10 plants compared with 64.1 for glucose alone. The figure for an adjacent standard plot was 7.5 fruits. Yields for these three plots per plant were 11.1 lb (glucose plus potash), 12.4 lb (glucose), and 10.7 lb (standard). The potash was found to have produced slight root damage though none could be seen on plants treated with glucose alone.

Nitrogen: Certain plots received four extra dressings of mineral nitrogen fertilizers throughout the October-December period. In all cases these extra nitrogen dressings reduced the susceptibility to cloud (Table VIII). Under the conditions of these experiments the effect of heavy nitrogen applications has been to reduce growth slightly and to produce a thinner stemmed, darker-coloured plant. There has been no stimulation to rankness of growth. The fruits on these plants on the whole have been smaller than on standard plots and thinner-walled. They were firm and the colour was very good.

TABLE VIII. EFFECT OF EXTRA NITROGEN ON THE INCIDENCE OF CLOUD

Treatment	Cloud	Yield (lb)	Blossom-end Rot
1950/51			
Standard Fertilizer	9.2	9.9	0.7
Standard Fertilizer + 12 oz. N per sq. yd.	0.9	9.1	9.1
1951/52			
Standard Fertilizer	88.4	11.5	0
Standard Fertilizer + 6.8 oz. sulphate of ammonia per sq. yd.	37.9	11.4	0

Note.—N represents a mixture of equal amounts of sulphate of ammonia and nitrate of soda.

Blossom-end Rot is expressed as number of affected fruits per 10 plants.

Figures represent the averages of two to three plots with each treatment.

It will be seen (Table VIII) that the extra nitrogen treatment was associated with a reduced amount of cloud in both seasons. In the 1950/51 season, the nitrogen treatment brought about an increase in the amount of blossom-end rot.

Nitrogen fertilizers were found to reduce the cloud-inducing effect of heavy-watering as will be seen from Table IX.

Table IX. Influence of Nitrogenous Fertilizers on the Cloud-Inducing Effect of Heavy Watering

Treatment		Yield (lb)	Cloud
1950/51			
Standard fertilizer	Standard water	9.6	2.9
Standard fertilizer	Extra Water	12.5	44.6
Standard fertiliser + 12 oz. N per sq. yd.	Extra water	11.5	12.9
1951/52			
Standard fertilizer	Standard water	11.0	63.7
Standard fertilizer	Extra water	11.4	101.1
Standard fertiliser + 8.4 oz. N per sq. yd.	Extra water	12.0	55.8

Note.—N represents equal quantities of sulphate of ammonia and nitrate of soda.

Nitrogen and Potash: Treatments supplying extra nitrogen and potash together have been to some extent more effective in reducing cloud than those supplying extra nitrogen or extra potash only. There has also been a decided improvement in fruit quality. Four dressings of sulphate of ammonia plus muriate of potash applied in solution along the rows at a total rate for each salt of 16 oz. per sq. yd. of the area of the plot, were completely effective in preventing the appearance of cloud in a glucose-treated plot. This treatment resulted in a reduction of one pound per plant in yield. Examination of the roots at the end of the season showed considerable damage near the surface and a development of a few abnormally thick roots at a lower level.

Calcium Chloride

In view of the possibility of salt effects from the quantities of nitrogen and potash used in these experiments, an attempt was made to determine the effect on cloud of frequent applications of a salt which could not be looked upon as supplying deficient nutrients to the plant. Calcium chloride was chosen, as a high level of calcium was present in both soil and standard fertilizer. It was applied in solution at the rate of 4 oz. per sq. yd. on four occasions, over the period 28 September to 24 November, making a total of 16 oz. per sq. yd. or 2 tons approximately, per acre. This salt eliminated cloud during the December pickings and only slight traces were found in January and February. The growth of the plant was reduced to some extent and the yield was less than for the corresponding standard treatment alone (9.1 lb per plant, compared with 11.5 lb for the standard plot). Calcium chloride was also effective in bringing about a considerable reduction in the amount of cloud produced by glucose.

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OBSERVATIONS ON YIELD AND VARIETAL SUSCEPTIBILITY OF SOME CARROT VARIETIES TO INSECT ATTACK IN THE FIELD

By K. P. Lamb, Plant Diseases Division, Department of Scientific and Industrial Research, Auckland

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Summary

The results of three field trials involving six carrot varieties are discussed with respect to yield, mean plant weight, and incidence of carrot aphid (*Cavariella aegopodii* Scop.) and carrot rust fly (*Psila rosae* F.). Osborn Park variety was the highest yielding and showed least damage from aphid attack; it was, however, the most heavily infested with carrot rust fly. Manchester Table variety was least infested with rust fly, but supported the most dense aphid populations and was the most damaged by aphids. Chantenay, Early Horn and James Intermediate were moderately damaged by aphid attack, and at maturity were moderately infested with rust fly. Holmes Improved variety was more vigorous and higher yielding than the previous group but lower yielding than Osborn Park.

Aphid densities and single leaf counts of aphids were significantly lower on Osborn Park than on Chantenay, James Intermediate, Early Horn or Manchester Table carrots. This may indicate some degree of aphid resistance in Osborn Park, but it is possible that this resistance was due (in part at least) to the greater vigour of the latter variety.

Introduction

The two major insect pests of carrots in New Zealand are the carrot aphid, *Cavariella aegopodii* Scop. and the carrot rust fly, *Psila rosae* F. The carrot aphid overwinters on willows and in the summer months winged forms migrate onto carrots and other umbelliferous plants where they give rise to wingless, parthenogenetic females which feed and reproduce on the foliage. They produce conspicuous quantities of honeydew and frequently cause the tops of carrots and parsnips to wilt. When attack is severe plants may be killed.

Several generations of the carrot rust fly are produced each year. The adult flies lay their eggs in the soil at ground level and the larvae feed on roots and form characteristic mines at or near the surface of the root. This feeding may produce stunting, dwarfing or complete destruction of plants—especially when they are attacked at an early stage of growth. Severely mined roots are unsaleable.

Experiments reported in this paper were designed primarily to compare aphid susceptibility between varieties. However, observations were also made on yield and rust fly incidence, and these data are included.

Experimental Procedure

Two field trials were carried out at the Plant Diseases Division, Auckland in 1950 and 1952, and one at Palmerston North in 1952. The results of these trials will be considered in turn.

1950 Field Trial (Auckland)

Seeds of the following varieties were sown on 18 November, 1949: Osborn Park, James Intermediate, Early Horn, Chantenay and Manchester Table. A randomized block design was employed, plots consisting each of four parallel rows 30 ft long and 18 in. apart. Each plot was separated from its neighbour by an equal sized plot of swede plants.

Single leaf counts of aphids were made early in March 1950. The third leaf from the centre of each of 40 plants of each variety was measured and the number of aphids recorded. At the conclusion of the trial on 27 March (140 days after sowing), 40 further plants of each variety were sampled and all aphids on their leaves were washed off into 10 per cent formalin and later counted in the laboratory. Weights of sample plants and row yields were recorded. Rust-fly infestation was assessed from both numbers of mined roots and numbers of mines in each root.

Aphid counts were found to be log-normally distributed so the log (n + 1) transformation was used in the analysis of variance of counts. The aphid density is expressed as the ratio

$$\frac{\log (n+1) \text{ aphids}}{\text{unit top weight}}$$

The results of this trial are summarized in Tables I, II and III.

TABLE I.

APHID INFESTATION OF CARROTS IN THE FIELD
(AUCKLAND, 1950)

Variety	Single leaves		Whole tops		
	Mean no. aphids per leaf	Mean of transformed counts	Mean no. aphids per plant	Mean of transformed counts	Aphid density
Osborn Park	9.7	0.31	52.7	1.37	0.23
Chantenay	11.7	0.82	72.9	1.48	0.55
James Intermediate	15.1	0.92	134.8	1.76	0.70
Early Horn	17.1	0.93	123.1	1.56	0.63
Manchester Table	34.9	1.34	174.6	2.03	1.30
Difference for significance 5%		0.24		0.24	0.16
1%		0.32		0.31	0.21

With the single leaf counts there was found to be no significant correlation between aphid numbers and leaf length. There was, however, significant correlation between aphid numbers and foliage weight ($r = + 0.198$). Thus aphid density is perhaps a better basis for varietal comparison.

Osborn Park had significantly less aphids per leaf than all other varieties at the first count and a significantly lower aphid density

at the second. Manchester Table on the other hand was significantly more heavily infested at both counts than any other varieties. The remaining three varieties did not differ significantly in extent of infestation (P = 0.01). Aphid damage was observed to be most severe on Manchester Table plants, moderate on Chantenay, Early Horn and James Intermediate, and negligible on Osborn Park. The low aphid density on Osborn Park may perhaps be explained in part by the size of the plants of this variety (see Table II).

TABLE II

YIELDS OF CARROTS IN THE FIELD (AUCKLAND, 1950)

Variety	Mean plant weight (g.)	Mean root weight (g.)	Mean foliage weight (g.)	Yield of roots per 30 foot row (lbs)
Osborn Park	176.5	121.1	55.3	23.6
Chantenay	85.8	62.5	23.3	12.5
Early Horn	71.7	52.6	19.1	12.3
James Intermediate	63.3	42.2	21.1	9.5
Manchester Table	36.2	27.4	8.8	7.6
Difference for significance 5%	28.8	19.7	12.9	3.0
1%	38.1	26.0	17.0	4.1

The yield from Osborn Park was approximately double that of any other variety (Table II). There was no significant difference between Chantenay, Early Horn and James Intermediate. Manchester Table carrots were significantly lower yielding than any variety except James Intermediate.

TABLE III

CARROT RUST FLY INFESTATION IN THE FIELD (AUCKLAND, 1950)

Variety	Mean per cent infested roots	Mean number of mines per 100 plants
Osborn Park	26.5	69.7
Chantenay	5.2	10.9
Early Horn	6.9	14.1
James Intermediate	4.7	10.6
Manchester Table	3.0	5.1
Difference for significance 5%	3.3	8.6
1%	4.4	11.7

Osborn Park had by far the highest percentage of rust fly infested roots and also the largest number of mines per 100 roots. The other varieties did not differ significantly in rust fly infestation with the exception of Manchester Table which was significantly less infested than Early Horn ($P = 0.05$).

The general level of infestation by aphids and rust fly was moderate, i.e. about the degree experienced in any average Auckland season.

1952 Field Trial (Auckland)

Three carrot varieties—Osborn Park, Holmes Improved and Chantenay—were sown on 28 November 1951 in single row plots ten feet long and one foot apart laid down in 3 x 3 latin squares replicated four times. Aphids were counted on ten plants per plot *in situ* in January. In April, ten plants per plot were lifted, weighed, observed for rust-fly infestation, and the aphids present were counted. The trial was concluded early in May 1952, when plot yields were determined and rust-fly incidence recorded.

Aphid counts were transformed as before, as also were counts of numbers of rust-fly mines per ten plants. In the final assessment, percentages of rust-fly-mined roots were determined and the percentages transformed to equivalent angles for analysis of variance. The aphid density was determined for the April samples by taking the logarithm of

$$\left[\left(\frac{\text{no. of aphids per 10 plant sample}}{\text{foliage weight of 10 plant sample}} \times \frac{100}{1}\right) + 1\right]$$

There was no significant difference between varieties in the the number of aphids per plant in the January samples, the antilogarithm of the general mean of the transformed data being 33. Other results of this trial are summarized in Tables IV and V.

TABLE IV

TABLE OF MEANS OF APRIL APHID SAMPLES AND FINAL YIELD OF CARROT FIELD TRIAL (AUCKLAND, 1952)

Variety	Mean number of aphids per plant	Means of transformed aphid counts	Aphid density	Mean foliage weight per plant (g.)	Mean root weight per plant (g.)	Yield of roots per 30 foot row (lbs)
Osborn Park	1.5	0.107	0.59	41.0	70.8	24.3
Holmes Improved	2.5	0.106	0.83	19.3	37.3	11.1
Chantenay	4.2	0.136	1.34	11.5	14.9	4.8
Difference 5% for significance 1%		0.018 0.026	0.11 0.16	11.2 15.2	12.9 17.5	4.5 6.3

TABLE V

CARROT RUST FLY INFESTATION (AUCKLAND, 1952)

Variety	Mean of transformed no. of mined roots per 10 pl. (April)	Mean transformed no. of mines per root	Mean per cent rust fly mined roots (end of trial)	
			Percentage	Equivalent angle
Osborn Park	0.53	0.54	74.5	59.7
Holmes Improved	0.32	0.51	73.2	58.8
Chantenay	0.36	0.38	52.8	46.6
Difference for significance 5%	0.09	not significant		11.0
1%	0.12			14.9

In order to assess the relative plant mortality during the trial the numbers of plants per row were counted in one latin square in January and again in April. Results, summarized in Table VI, show that highest mortality occurred with Chantenay, less with Holmes Improved, and least with Osborn Park.

TABLE VI

RELATIVE SURVIVAL OF CARROT PLANTS IN THE FIELD (AUCKLAND, 1952)

Variety	Mean number of plants per row	
	January count	April count
Osborn Park	36	35.0
Holmes Improved	31	28.3
Chantenay	33	23.0
Difference for significance 5%	not significant	2.15
1%		4.96

In this trial, Chantenay was found to have the most aphids per plant and also the highest aphid density. There was no significant difference in mean number per plant on Osborn Park and Holmes Improved varieties but Holmes Improved plants had a significantly higher aphid density than Osborn Park plants. Osborn Park plants had the highest mean root weight, while roots of Holmes Improved plants were on the average over twice the weight of those of Chantenay. The mean crown weight of Osborn Park plants exceeded that of the other two varieties. The vigorous

growth habit of Osborn Park was reflected in its higher yield and better survival in comparison with other varieties. The yield of Holmes Improved, though less than half that of Osborn Park, was more than double that of Chantenay. Varieties did not differ significantly in mean number of mines per root but Chantenay had a significantly lower percentage of infested roots than either Holmes Improved or Osborn Park. The level of aphid infestation was low when the plants were sampled, though it had been higher earlier in the season. The heavy early infestation might account in part for the higher mortality of Chantenay and Holmes Improved plants (Table VI), though dry climatic conditions were possibly also partly responsible.

1952 Field Trial (Palmerston North)

This trial was identical in layout with the 1952 Auckland field trial, except that Manchester Table variety was substituted for Holmes Improved variety. Seed was sown on 9 November 1951 and the trial was sampled in May 1952. Infestation with both aphids and rust fly was very low in this trial and plants were adversely affected by unfavourable weather conditions. No significant differences were found in aphid numbers or rust-fly infestation between varieties. Yields are summarized in Table VII.

TABLE VII

YIELDS OF CARROTS IN THE FIELD (PALMERSTON NORTH, 1952)

Variety	Mean root weight (g.)	Mean foliage weight (g.)	Yield of roots per 30-foot row (lbs)
Osborn Park	66.3	7.2	31.8
Chantenay	31.5	2.7	23.1
Manchester Table	29.0	2.2	24.0
Difference for significance 5%	9.9	2.1	3.3
1%	13.4	2.9	4.5

Once again Osborn Park was the highest yielding variety. No significant difference was found in yield, mean root weight or mean crown weight between Manchester Table and Chantenay plants. In this trial the plant tops had not been thinned as rigorously as in the Auckland trials.

Discussion and Conclusion

For high yield and vigour, Osborn Park emerges as an outstanding variety in these trials. It was followed by Holmes Improved. The group comprising Chantenay, Early Horn and James Intermediate was more or less homogeneous in most respects. Manchester Table was the lowest yielding variety in the Auckland trials. All varieties were suitable for table use.

Under conditions of moderate aphid infestation, Manchester Table plants supported the most dense aphid populations and these plants were severely damaged as a result. Osborn Park plants

had the lowest aphid density and showed least damage while the group comprising Chantenay, Early Horn and James Intermediate supported aphid populations of moderate density and showed a moderate amount of damage. The aphid numbers on Holmes Improved plants in the 1952 trial were too small for an adequate assessment of plant damage.

Insect resistance depends on the interaction of plant genotype with environment. It may vary from place to place and from season to season. A variety may have considerable inherent vigour and thus be able to throw off the effects of aphid attack. While this appeared to be the case with Osborn Park, vigour alone may not be sufficient to account for the low aphid densities found on this variety. Less vigorous varieties will succumb more readily to aphid attack. This appeared to be, at least, a contributing reason for the damage suffered by Manchester Table plants. However, the apparently low vigour of this variety may have resulted from the large aphid populations on Manchester Table plants. An observation made during these trials was the rapid rate at which aphid populations could change in the field, depending upon such factors as rain, temperature, humidity or aphid flights. These observations suggest that it is essential to take a dynamic view of aphid populations in the field rather than a static one. Only a limited amount can be learnt from a single count of insects on a group of plants in any particular season or locality. From the field data collected in the above trials it did not appear that any of the varieties tested possessed any marked inherent resistance to the carrot aphid in the sense that they would not support reproducing aphid populations. However, the small populations and low aphid densities encountered on Osborn Park carrots suggest that this variety, at least, may have some degree of resistance to the carrot aphid.

In none of these trials was the incidence of rust fly as high as is sometimes encountered in carrot growing districts. However, it was apparent that Osborn Park plants were the most severely attacked. At maturity an appreciable proportion of these roots was so badly damaged as to be unsaleable. These results must however be interpreted with caution as it is possible that some of the plants of other varieties could have been killed out completely at an early stage by rust-fly attack.

It would appear that Osborn Park and possibly Holmes Improved varieties would be better suited for areas where carrot aphis is a serious problem but carrot rust fly is not. Manchester Table variety on the other hand would appear to be less suited for such areas.

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WOOL QUALITY AND FLEECE WEIGHT

By A. E. Henderson, Canterbury Agricultural College, Lincoln

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Summary

The relationship between wool quality 'judged subjectively and expressed by Bradford count numbers, and both greasy and clean fleece weight, has been established by examining extensive flock data involving several breeds.

Regression coefficients expressing differences in average fleece weight between quality groups showed in all cases a fall in fleece weight with increasing fineness of wool. In a majority of instances the regression coefficient was significant. However, the size of the regression coefficient could not be correlated with any other productive feature of the flock.

Analysis of variance showed highly significant differences between breed groups in the size of the regression coefficient. There was a progressive increase in the size of the coefficient with increasing wool fineness of the breed.

Highly significant differences between flocks within breeds were found. These differences could not be satisfactorily explained except to agree with a previous suggestion that differences may be the result of productive peculiarities of particular strains of sheep within breeds. No conclusive evidence could be advanced in support of this suggestion.

Introduction

It is often admitted that a relationship exists between fleece weight and wool quality. However, little factual evidence has been published. Reporting on a survey of range wool production and shrinkage, Burns (1948) shows that there is a progressive fall in both greasy and clean fleece weight with increasing fineness of wool and he quotes Pohle and Keller (1944) who published data showing similar trends. A more detailed analysis of the fibre-diameter—fleece-weight relationship for a number of breeds and crosses was carried out by Slen (1949) and he found that when the complete data were considered a well defined relationship was apparent. However, within groups of the one breed or cross he found little evidence to support the previous finding and concluded that within such groups the relationship was of no practical importance. A similar inconsistent relationship is apparent in a report by Jones *et al.* (1944) who examined wool growth on Rambouillet sheep.

In this report extensive fleece-weight, wool-quality data, relating to several breeds, have been analysed to show the nature of the relationship between wool quality and fleece weight.

Source of Data

Conclusions reached here are based on analysis of fleece data obtained when carrying out a wool survey project (McMahon, 1941, 1942), designed to obtain basic information on wool production within the ordinary commercial flock. Flocks examined were of three breed groups, Romney and Crossbred, Three-quarter-bred

(usually a cross between Romney and Corriedale, or Half-bred sheep), and Corriedale and Half-bred sheep, the latter being flocks founded on a cross between Merino and either Romney, Lincoln or English Leicester sheep and maintained by the use of first cross rams. In each breed group, environmental conditions, particularly nutrition, varied widely from flock to flock, and in many cases wool production of a particular flock was examined in successive years.

In the field, individual fleeces (excluding belly wool) were weighed, a subjective appraisal of wool quality was made, and a small sample was withdrawn from the hip region of the fleece. These small samples were bulked according to quality group and were subsequently scoured to provide yield figures from which clean fleece weights were calculated.

Without exception, the data dealt with here concerns flocks of mixed-age breeding ewes, and in no case does the flock contain fewer than 200 sheep. In most instances more than 500 sheep are involved.

TREATMENT OF DATA

Bradford count numbers were used to describe wool quality, and in the field half-count intervals were employed. To make calculation less onerous, data pertaining to fleeces appraised in intermediate half counts have been added to that of the nearest whole count above. Observer differences in quality estimation have been corrected, using a series of regression equations calculated by Short (1946).

The construction of bar graphs showing the average fleece weight of sheep within the separate quality groups found in a flock, indicated that the fleece-weight differences between adjacent qualities were approximately equal. It was, therefore, decided that a regression coefficient would provide a concise and accurate measure of these differences and would allow tests of significance to be made. Accordingly, coefficients expressing the regression of fleece weight on wool quality were calculated for each flock, in many cases for more than one year. The regression coefficients so calculated express the rate of decrease of fleece weight (lb) with each successive increase in wool quality, measured in whole count intervals according to the Bradford count system.

RESULTS

General Relationship

Regression coefficients and average fleece weight for years and for flocks are shown in Table I.

Regression coefficients are, without exception, negative, and it will be noted that most are highly significant although they vary a great deal in value. The large number of significant regression coefficients and the consistent trend clearly indicate that in the ordinary flock, and when wool quality is judged subjectively, there is a real and consistently occurring fall in fleece weight with increasing fineness of wool. These results are at variance with those of Jones *et al.* (1944) and Slen (1949), in that they show a clear

TABLE I. REGRESSION OF FLEECE WEIGHT ON WOOL QUALITY

Flock	Average Fleece Weight (lb)		Regression Coefficient "b"		Mean Flock Fleece Weight (lb)		Mean Flock Regression Coefficient "b"	
	Greasy	Clean	Greasy	Clean	Greasy	Clean	Greasy	Clean
ROMNEY AND CROSSBRED								
1	7.9	5.7	-0.25	-0.25				
	10.0	7.0	-0.07	-0.26	8.95	6.35	-0.16	-0.26
2	9.9	7.5	-0.57**	-0.46**				
	9.6	7.4	-0.46**	-0.20				
	10.5	7.9	-0.49**	-0.47**				
	9.8	7.0	-0.44*	-0.28*				
	9.6	7.2	-0.22	-0.29	9.88	7.40	-0.44	-0.34
3	9.4	7.3	-0.44**	-0.42**				
4	8.8	7.8	-0.28**	-0.32**				
5	10.2	7.9	-0.50**	-0.48**				
6	8.9	6.8	-0.58**	-0.60**				
7	9.1	6.6	-0.30**	-0.30**				
	8.4	6.2	-0.20*	-0.22**				
	9.6	7.0	-0.17	-0.18				
	7.9	5.8	-0.30**	-0.34**				
	10.3	6.9	-0.36*	-0.33*	9.06	6.50	-0.27	-0.27
8	9.9	7.5	-0.60**	-0.55**				
9	6.4	4.8	-0.52**	-0.44**				
	7.3	5.4	-0.29**	-0.32**				
	6.7	5.0	-0.23*	-0.26**	6.80	5.07	-0.35	-0.34
10	8.7	6.5	-0.35**	-0.37**				
	9.1	6.7	-0.29**	-0.34**				
	7.0	5.2	-0.21	-0.26*	8.27	6.13	-0.28	-0.32
11	9.2	7.0	-0.27**	-0.19				
12	9.2	7.3	-0.33**	-0.41**				
	9.5	7.6	-0.22*	-0.32**				
	10.3	8.4	-0.36**	-0.44**	9.67	7.77	-0.30	-0.39
13	6.3	4.5	-0.18**	-0.22**				
	6.6	4.3	-0.23**	-0.22**	6.45	4.40	-0.21	-0.22
14	9.2	6.4	-0.36	-0.41**				
	11.0	7.9	-0.17	-0.28**	10.10	7.15	-0.27	-0.35
15	7.6	5.7	-0.60*	-0.57**				
	8.2	6.2	-0.42**	-0.38**	7.90	5.95	-0.51	-0.48
16	6.7	5.1	-0.24*	-0.29**				
17	8.0	5.8	-0.10	-0.14				
18	6.0	4.5	-0.39**	-0.37**				
	7.3	5.3	-0.35**	-0.30**				
	6.2	4.6	-0.19**	-0.20**				
	6.8	4.8	-0.30**	-0.33**	6.58	4.80	-0.31	-0.30
19	5.7	4.2	-0.34*	-0.31*				
	7.2	5.2	-0.30	-0.31*				
	7.2	5.2	-0.29	-0.36**	6.70	4.87	-0.31	-0.33
20	9.7	7.2	-0.50**	-0.51**				
21	8.3	5.9	-0.13*	-0.25**				

Table I. (contd)

Flock	Average Fleece Weight (lb)		Regression Coefficient "b"		Mean Flock Fleece Weight (lb)		Mean Flock Regression Coefficient "b"	
	Greasy	Clean	Greasy	Clean	Greasy	Clean	Greasy	Clean
22	10.0	7.8	-0.28**	-0.35**				
	9.2	6.9	-0.29*	-0.28**				
	10.2	7.7	-0.46**	-0.44**				
	9.3	6.9	-0.35**	-0.37**	9.68	7.33	-0.35	-0.36
23	10.6	8.3	-0.35**	-0.32**				
	9.3	7.3	-0.50**	-0.42*				
	9.5	7.6	-0.56*	-0.43*	9.80	7.73	-0.47	-0.39
24	10.1	7.6	-0.57**	-0.45**				
				MEAN	8.45	6.27	-0.325	-0.335
THREE-QUARTER BRED								
1	9.5	6.5	-0.25**	-0.32**				
	8.3	5.6	-0.32**	-0.36**	8.90	6.05	-0.29	-0.34
2	8.2	6.2	-0.36**	-0.39**				
3	7.1	5.2	-0.26**	-0.34**				
	7.5	5.3	-0.21**	-0.30**	7.30	5.25	-0.24	-0.32
4	8.5	6.3	-0.44**	-0.51**				
5	10.1	7.1	-0.92**	-0.77**				
6	6.3	4.8	-0.17**	-0.22				
7	7.6	5.8	-0.26	-0.24*				
	6.6	5.1	-0.58*	-0.59**				
	8.6	6.2	-0.42*	-0.32				
	6.6	4.7	-0.41**	-0.26	7.35	5.45	-0.42	-0.35
8	8.2	6.0	-0.53**	-0.50**				
	8.5	6.3	-0.51**	-0.39**	8.35	6.15	-0.52	-0.45
9	8.7	5.9	-0.38**	-0.40**				
				MEAN	7.98	5.73	-0.368	-0.365
HALF BRED AND CORRIEDALE								
1	8.8	6.1	-0.41**	-0.40**				
2	5.4	3.2	-0.52**	-0.45**				
	5.5	3.5	-0.51**	-0.46**	5.45	3.35	-0.52	-0.46
3	6.9	4.7	-0.29**	-0.41**				
4	10.5	6.9	-0.58**	-0.52**				
	9.4	6.6	-0.93	-0.78*				
	9.4	6.2	-1.14*	-0.88**	9.77	6.57	-0.88	-0.70
5	5.5	3.3	-0.40**	-0.28**				
	6.5	3.8	-0.40**	-0.42**				
	5.6	3.6	-0.35**	-0.37**	5.87	3.57	-0.38	-0.36
6	7.8	5.0	-0.18**	-0.24**				
	7.4	4.9	-0.27	-0.25				
	6.1	4.4	-0.38**	-0.37**	7.10	4.77	-0.28	-0.29
7	6.1	3.2	-0.32*	-0.26**				
	5.5	2.9	-0.12	-0.16				
	5.9	3.7	-0.40	-0.60**				
	5.1	3.2	-0.57**	-0.38*	5.65	3.25	-0.35	-0.35
8	8.0	5.7	-0.47**	-0.43**				
	6.4	4.2	-0.33**	-0.34**	7.20	4.95	-0.40	-0.39
9	8.1	5.1	-0.39	-0.60**				
10	7.3	4.9	-0.66	-0.76**				
11	6.1	4.2	-0.47**	-0.47**				
				MEAN	6.84	4.41	-0.468	-0.425

* sig. at 5% level
** sig. at 1% level

relationship within a breed. The different conclusions may result from the use in the present study of subjective appraisal of wool quality in which judgment is made according to preconceived and personal standards, and the use by the above authors of actual measurement of fibre diameter. It is well known that estimation of fibre diameter by eye leaves much to be desired in the way of accuracy and there is no reasonable doubt that a number of features of the fleece, for instance crimp and length, influence subjective estimations of quality. There is a possibility, therefore, that length of staple and size of fleece, which are associated with fleece weight, influence subjective estimation of quality. If this is so, then a small correlation of fleece weight and wool quality is likely to occur as an artifact created by the observer. This, no doubt, could lead to fundamental inaccuracy of the data. However, it must be remembered that objective means of wool appraisal are very seldom employed in practice. The producer, and all those who handle wool during its utilisation, use subjective means of appraisal, and if the practical usefulness of subjective appraisal is admitted, and there can be little doubt that it is, then the regression coefficients in Table I reveal a real and characteristic trend in wool production within flocks.

Regression coefficients for the same flock and year, but calculated using greasy and clean fleece weights respectively, are similar ($r = 0.828^{xx}$). Although it is the more correct to base calculations on clean weights, such are seldom available except on a laboratory scale. However, since greasy weight regressions are closely similar, the latter may confidently be used in circumstances where clean fleece weights are not readily available.

Effect of Breed

Analysis of variance of both greasy- and clean-weight regressions showed that differences between breeds were highly significant. The three breed groups showed a progressive increase in the size of the mean regression coefficient, according to increasing wool fineness of the breed (Table II). Reference to Table I, however, shows a great deal of overlapping of breed groups and the importance of the differences is thus somewhat obscure. It is likely that individual flock peculiarities are of more importance.

Table II. Mean Regression of Fleece Weight on Wool Quality For Breed Groups

Breed Group	Regression Coefficients (mean of flock means) Greasy	Clean	Quality Range of Breed Groups
Romney and Crossbred	—0.325	—0.335	46-54
Threequarter-bred	—0.368	—0.365	50-56
Halfbred and Corriedale	—0.468	—0.425	54-64

Flock Differences

Differences between flocks within breed groups also proved highly significant but a search for factors which could possibly be responsible for, or associated with, flock differences, proved negative. The size of the regression coefficient could not be corelated with either greasy or clean fleece weight, average wool quality of a flock, character of wool, or with the degree of selection practised within the flock. In a previous interim report (McMahon, 1942), based on partial analysis of this data, it was suggested that there was a well defined relationship between environmental conditions and the size of the differences in fleece weight between groups. Where average fleece weights were high there was a marked fall in fleece weight with increasing fineness of wool. Conversely, where fleece weights were low, differences between quality groups were small. In a later report McMahon (1944) records instances where opposite trends occurred and suggests that strain of sheep may play an important part in determining the fleece-weight — wool-quality relationship. Since, in the present data there is no support for the contention that average fleece weight of the flock and rate fall in fleece weight with increasing fineness of wool are associated, more emphasis can perhaps be accorded McMahon's later statement that strain may be responsible for flock differences. However, examination of regression coefficients for flocks where wool production was examined over several years, in most cases successive, reveals rather inconclusive evidence in favour of the influence of strain. Fluctuations in size of regression coefficients within most flocks obey no particular pattern and cannot be due to deliberate attempts to change strain, which can happen only at a relatively slow rate. Nevertheless, some flocks show good year-to-year consistency and it is possible that real strain effects are partially masked by some unrecorded influence such as chance selection of the small numbers of sheep which comprise the quality groups at either end of the quality range found within a flock.

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FEED VALUE OF MEAL WHEN USED AS A SUPPLEMENT TO SKIM-MILK FOR PIG FEEDING

By D. M. Smith, Ruakura Animal Research Station, Department of Agriculture, Hamilton, New Zealand

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Summary

(1) Twenty-four pigs from eight litters were fed three rations differing in the proportion of meal and separated milk.

(2) The results showed that similar growth rate and dry-matter requirement per pound of gain obtained irrespective of the proportions of milk and meal in the ration.

(2) The conclusion is that under the conditions of feeding in New Zealand, where meal supplements separated milk, the food value of a gallon of milk and a pound of meal is practically identical.

Introduction

Dairy by-products such as separated milk, buttermilk and whey are the pig foods in most general use in New Zealand. The supply of these foods varies from almost zero in the winter months to a peak in November and then falls again as the dairying season advances. To the pig producer, this seasonal fluctuation poses the problem of fitting pig numbers, requirements for rapid growth, and appetite, to the available supplies of feed over the year.

The problem is met by: (a) a suitable arrangement of farrowing dates; (b) flexibility in marketing practices; and (c) the use of supplementary foods in times of milk scarcity.

The aim is to have on hand sufficient pigs with large enough appetites to consume the rapidly rising milk production during September and October. The appetite and requirements of this number of animals when weaned in July and early August will exceed the supply available at this time. It is only by supplementing this milk ration until more becomes available that the weaners can be grown by September to a size and weight at which they are capable of consuming the skim-milk produced in this and subsequent months. The amount and type of supplement used is a matter of economics. As a necessary preliminary to a study of the profitability of the use of a meal mixture with separated milk, the present experiment was designed to investigate: (a) the comparative food value of separated milk and meal when the latter is used as a supplement; and (b) the effect of reducing the level or stopping the use of meal upon the growth rate and the efficiency of food conversion. This latter phase of the experiment was included since the aim and practice, as described previously, is to replace any supplement used with milk as the supply becomes more plentiful. This change in ration could conceivably cause digestive disturbances and reduced growth rate.

MATERIAL AND METHODS

Twenty-four pigs from eight litters were allotted at weaning to three treatments on a restricted random basis, the restriction being equal numbers of males and females on each ration. All pigs were individually fed.

Since the average weaning weight of the animals used was above 40 lb, the trial commenced as each pig reached 50 lb live weight. Prior to this weight, all pigs were similarly fed. The experiment covered the range of 50-110 lb and weights were recorded twice weekly.

The three pigs from each litter were allotted to the following treatments:

Treatment 1. Skim-milk alone from 50 to 110 lb live weight.

Treatment 2. Skim-milk + 1½ lb meal daily from 51 to 70 lb live weight;
Skim-milk + 1 lb meal from 71 to 90 lb live weight;
Skim-milk alone thereafter to 110 lb.

Treatment 3. Skim-milk + 1½ lb meal daily from 51 to 70 lb live weight;
Skim-milk + 1 lb meal from 71 to 110 lb.

The meal mixture used consisted of 1 part by weight of 60% protein meat meal to 3 parts of barley meal.

The animals were fed on a pre-set weight of dry matter daily according to live weight. The ration is shown in Table I. In this scale 1 lb meal and 1 gal milk were considered equal in terms of dry matter. (Separated milk, 9% D.M.; meal, 89.7% D.M.). The premise adopted was that since all pigs were to make the same total weight gains, any difference in the food value of the two foodstuffs would show as differences in dry matter requirements.

TABLE I. DAILY RATIONS FED TO PIGS ACCORDING TO LIVE WEIGHT

Live weight (lb)	Ration 1		Ration 2		Ration 3	
	Milk (Gal)	Meal (lb)	Milk (Gal)	Meal (lb)	Milk (Gal)	Meal (lb)
50	2.0	—	0.75	1.25	0.75	1.25
51—55	2.25	—	0.75	1.5	0.75	1.5
56—60	2.5	—	1.0	1.5	1.0	1.5
61—65	2.75	—	1.5	1.25	1.5	1.25
66—70	3.0	—	2.0	1.0	2.0	1.0
71—75	3.25	—	2.25	1.0	2.25	1.0
76—80	3.5	—	2.5	1.0	2.5	1.0
81—85	3.75	—	2.75	1.0	2.75	1.0
86—90	4.0	—	3.5	0.5	3.0	1.0
91—95	4.0	—	4.0	—	3.0	1.0
96—100	4.25	—	4.25	—	3.25	1.0
101—105	4.50	—	4.5	—	3.5	1.0
106—110	4.75	—	4.75	—	3.75	1.0

Table II. The Mean Performance of the 8 Pigs on Each of 3 Treatments

	Treatment 1	Treatment 2	Treatment 3
Weight at commencement (lb)	50.4	50	50.5
Final weight (lb)	109.5	109.6	110.6
Weight gain (lb)	59.1	59.6	60.1
Units dry matter eaten			
as milk	159.25	113	100.5
as meal	Nil	48	61.25
Total	159.25	161	161.75
Dry matter per lb gain	2.69	2.69	2.69
Days	54	54	54
Gain per day (lb)	1.09	1.11	1.12

Results

The essential features of Table II are:

(1) Approximately the same mean total weight-gain was made by the pigs on the three treatments;

(2) A similar quantity of dry matter was consumed to achieve these weight gains;

(3) The proportions of the total dry matter consumed as milk and as meal differed as between treatments.

If a food value of x units for a gallon of milk and y units for a pound of meal is assumed, then:

In Treatment 1, 159.25x produced 59.1 lb gain;

In Treatment 2, 113x + 48y produced 59.6 lb gain;

In Treatment 3, 100.5x + 61.25y produced 60.1 lb gain.

Solving x in Treatment 1 gives a value of 0.371. When this value is used for Treatments 2 and 3, y then equals 0.369 and 0.372 respectively. From these calculations 0.37 lb of gain are produced by the intake of one gallon of milk or one pound of meal.

It is concluded that the food values of a gallon of milk and of a pound of meal, as fed in this experiment, were similar.

Table III. Relationship between Food Units Consumed and Weight Gains

(Mean of groups)

(1 Food unit = 1 gal of milk = 1 lb of meal)

Treatment	Food Units per lb gain for weight ranges			
	51 to 70 lb	71 to 90 lb	91 to 100 lb	Total 51 to 110 lb.
1	2.23	2.74	3.14	2.69
2	2.25	2.73*	3.10†	2.69
3	2.31	2.71*	3.11	2.69

* Meal reduced from 1½ lb daily to 1 lb.

† Meal ration eliminated.

The second problem to which this investigation sought an answer was whether curtailing or eliminating the daily ration of

meal would cause any reduction in efficiency of food conversion. Table III shows the food requirement per pound of gain over the three successive 20-lb ranges involved in the total 60-lb gain.

It is clear that sudden reduction or elimination of the meal ration and its replacement by milk has not resulted in any increase in food requirement per pound of gain, and the data in Table II show that the daily gain over the whole experimental period was essentially the same for all groups.

DISCUSSION

There are in the literature dealing with pig nutrition many references to the relative food value of skim-milk and various meals or grains. Bishop (1937) and Stewart (1934) quote 6 lb of skim-milk as being equal in food value to 1 lb of meal. Day (1914) and Henry and Morrison (1922) consider that from 3.5 to 5.7 lb of milk equal 1 lb of meal, depending on the level at which milk is fed. Henry and Morrison are emphatic that the proportion of milk in the ration will determine the value to be assigned to this material. To quote these authors: "After sufficient milk has been supplied to balance the ration, any addition will not increase the rate of gain materially and may even lower it if too much is fed." Crowther (1932) also suggests that as little as 1 pint of milk per day, plus meal, should be fed to obtain maximum value from this food.

It will be noted that the theme of all the workers quoted above is that of supplementing meal with skim-milk. In most of these cases milk fills the role of a protein supplement to grain—a supplement of high biological value. Under New Zealand conditions the position is exactly the reverse. Here, the practice is to supplement a skim-milk ration with meal, and in many cases the mixture used has at least a proportion of meat-meal in it, since this meal is usually the cheapest on the local market.

It is probable that the combined effect of both the high protein content of the meal used, and the high level of milk feeding, account for the relatively low value which must be credited to separated milk under New Zealand conditions of pig feeding.

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ZINC DEFICIENCY IN PEARS

By E. G. Bollard, Fruit Research Station, Department of Scientific and Industrial Research

(*Received for publication, 15 December 1952*)

Summary

The occurrence of zinc deficiency in pear trees in Central Otago is recorded. Symptoms consist of leaf chlorosis, reduction in leaf size, suppression of growth and die-back of leaders.

Normal growth was restored by summer, autumn or winter sprays of 3 lb zinc sulphate mixed with 4 lb hydrated lime and 50 gal water.

Introduction

Although a deficiency of zinc is known to cause a serious disorder of fruit trees in many parts of the world, there are only two unsubstantiated reports (Forester, 1947; Reynolds, 1947) of such a disorder in New Zealand. The present paper records the presence of zinc deficiency in pears in a severe form in Central Otago and describes diagnostic experiments.

The affected trees were twelve years old, variety Williams Bon Chretien, and were growing in a soil of pH 6.7 in the Alexandra district. A soil profile showed 15 in. of loose sand overlying 27 in. of sandy loam.

Symptoms

Growth on the lower parts of affected trees is often apparently normal. Symptoms are usually apparent on growth arising half way up the tree, and become progressively worse towards the tips of the leaders. (Fig. 1). The lowest leaves with symptoms show only a diffuse mottle. Further up the tree, leaves are, in addition, smaller; toward shoot tips they may be less than a quarter normal size. Some rosetting of foliage is apparent, but in pears this symptom does not appear to be so characteristic as in other fruits.

Toward the tops of leaders growth is much reduced, in many cases the buds failing to grow, and leaders may show no apparent growth for 2–3 ft from the tip. In the most severely affected trees, die-back of the leaders occurs. Symptom development within a tree is sometimes irregular, one leader may be showing severe die-back while the others show only slight symptoms.

Field Trials

In trials described below all sprays consisted of 3 lb zinc sulphate plus 4 lb hydrated lime in 50 gal water. On 11 December, 1950, twelve affected trees were sprayed. Within two months these trees showed a response in contrast to unsprayed controls. New growth with dark green, normal sized leaves was apparent in the upper parts of treated trees.

Further treatment of these twelve trees differed:

(a) Four received a further spray in the autumn—applied 16 March, 1951;

(b) Four recived a dormant spray—applied July, 1951;

(c) Four received a further spray in the next spring—applied 12 November, 1951.

In addition four trees, which had received no foliage spray, received a dormant spray.

By the end of the 1951-52 season all treated trees showed considerable improvement over those untreated. The trees which had received dormant or autumn sprays were better than those which had received two spring sprays, as the latter still showed "little-leaf" symptoms. All treated trees held their leaves later than untreated.

LEAF ANALYSIS

Samplings were made from check trees in the above experiment and from apparently healthy trees of the same variety growing in another part of the Alexandra district. Leaves for analysis were selected in each instance from the lower part of current season's growth. Zinc determinations were made by Miss T. Marwick, Soil Bureau, Department of Scientific and Industrial Research.

Source of material	Date of sampling	Zinc content (p.p.m. Zn in dry weight)
Deficient trees, Alexandra	22/2/52	9.9
Healthy trees, Alexandra	22/2/52	16.0

There appear to be no other published figures for zinc levels in pear trees, but it is interesting to compare the above figures with those from apples.

Chandler *et al* (1934) found zinc levels in deficient apple leaves ranging from 4 to 54 p.p.m., and in apparently healthy leaves from 4 to 80 p.p.m. Thomas *et al* (1949) state the deficiency symptoms do not appear in apples unless the zinc content is less than 14 p.p.m. Bould *et al* (1949) found a zinc level of 9.6 p.p.m. in healthy apple leaves, while leaves from affected trees had only 1.2–2.3 p.p.m.

CONTROL

The present work is not extensive enough to favour any one spray programme as a method of remedying this deficiency. It does, however, suggest that if zinc is applied annually as a 6-8-100 spray, normal growth will be maintained.

INCIDENCE

A similar response to zinc sprays has been obtained in two other pear blocks in the Alexandra district, and it is possible that this deficiency may be present in other orchards. Zinc deficiency in pears has not yet been reported from any other part of New Zealand.

Fig. 1.—Pear tree, var. Williams Bon Chretien, showing suppression of growth and "little leaf" symptoms of zinc deficiency.

Photo: S. A. Rumsey.

Acknowledgments

The writer wishes to acknowledge the co-operation of Mr. G. R. Campbell, Alexandra, who permitted use of his trees. Thanks are due to Mr. S. Kemp, Horticulture Division, Department of Agriculture, for assistance with recording; and to Miss T. Marwick and Mr. J. D. McCraw, Soil Bureau, Department of Scientific and Industrial Research, for carrying out the analyses and for the soil profile information respectively.

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NOTE ON THE SYSTEMIC NATURE OF APPLE-MOSAIC VIRUS IN APPLE TREES

By E. E. Chamberlain, Plant Diseases Division, J. D. Atkinson, Fruit Research Station, and J. A. Hunter, Plant Diseases Division, Department of Scientific and Industrial Research, Auckland

(Received for publication, 13 October 1952)

Introduction

Atkinson and Chamberlain (1948) have shown that apple-mosaic virus is widespread in New Zealand and that incidence is high, particularly in Jonathan and Golden Delicious apples. A search has been made in the five major fruit growing districts for healthy trees of these two varieties to provide budwood for propagation. Although many hundreds have been examined no bearing trees free from mosaic symptoms have yet been found. Some trees of these varieties, however, show symptoms on a few leaves only, and sometimes in only one part of the tree. This has led to speculation as to whether buds taken from those parts of infected trees not showing symptoms would give rise to healthy trees.

Louw (1944) stated that the disease was transmitted by buds from axils of apparently healthy leaves occurring on infected trees. In his experiments, however, the apparently healthy leaves, from the axils of which buds were taken, were adjacent to leaves showing infection.

An experiment was therefore planned to secure further information on distribution of the virus in infected trees.

Experimental Methods

The following types of buds were taken from nine clonal Johnathan apple trees showing moderate apple-mosaic symptoms:

A. Buds from axils of leaves showing symptoms. Buds were taken from annual shoots on which one or more leaves showed definite symptoms but which also carried apparently healthy leaves either above or below those showing symptoms.

B. Buds from the same budwood sticks as A but from axils of symptomless leaves situated immediately above leaves showing symptoms.

C. Buds from the same budwood sticks as A but from axils of symptomless leaves situated immediately below leaves showing symptoms.

D. Buds from annual shoots occurring on branches where no leaves showed symptoms.

Buds A and D were worked to 36 Jonathan apple seedlings (arranged in plots of six) and buds B and C to 18 seedlings

(arranged in plots of three). Plots were randomised within four nursery rows with one or more unbudded seedlings as checks between each plot.

Both scions and stocks were allowed to grow in the following spring and observations for presence of symptoms made in December ten months after budding.

Results

Results of observations for apple-mosaic symptoms are given in the following table:

TABLE I. EFFECT OF BUDS FROM DIFFERENT PARTS OF INFECTED TREES ON DEVELOPMENT OF APPLE-MOSAIC SYMPTOMS IN STOCK AND SCION GROWTHS OF BUDDED APPLE SEEDLINGS

(Scion variety: Jonathan. Records taken 10 months after budding)

Place of origin of buds on infected trees	No. of trees budded	Apple-mosaic symptoms in			Total trees showing symptoms	
		Scions only	Stocks only	Scions & stocks	No.	%
A. Axil of leaf showing symptoms	36	3	6	15	24	66
B. Axil of symptomless leaf above A	18	0	8	6	14	78
C. Axil of symptomless leaf below A	18	1	4	8	13	72
D. Branch showing no symptoms	36	3	13	5	21	58
Checks: 32 seedling stocks, not budded, showed no symptoms.						

It may be seen that a high percentage of trees developed symptoms in either scion or stock or both, irrespective of whether buds were secured from axils of leaves showing mosaic symptoms or from axils of apparently healthy leaves. When buds were selected from branches where no symptoms occurred the percentage of trees developing symptoms was almost as great as when buds were secured from axils of leaves showing symptoms.

Conclusion

Results show that apple-mosaic is systemic in infected trees. It is therefore evident that mosaic-free trees can be obtained only if budwood is taken from virus-free trees and worked to virus-free stocks.

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RESISTANCE OF SWEDES TO APHIDS
I. RESISTANT VARIETIES

By T. P. Palmer, Crop Research Division, Department of Scientific and Industrial Research, Christchurch

(*Received for publication, 22 September 1952*)

Summary

Of 45 lines of swedes grown at Lincoln in the season 1951-52, the following exhibited sufficient resistance to aphids to withstand heavy attacks in the field: Calder, New Zealand Sensation (yellow and white fleshed varieties), Wilhelmsburger Otofte, Bangholm Wilby Otofte, Granhovsdet Hunsballe, Balder and Vilmorin's White fleshed green-top.

Introduction

So far as the author is aware, no surveys of varietal resistance of swedes (*Brassica napus* L. var. *napo-brassica* L.) to aphids (*Brevicoryne brassicae*) have been made. This paper reports the reaction of 45 lines of swedes to a heavy aphis attack in the autumn of 1952.

Experimental Methods

The varieties were arranged in a simple lattice trial of four replications. Plots consisted of one row 30 ft long, with a variable number (0 - 40) bulbs per row, and a susceptible (Superlative) buffer between each row. Only two varieties gave empty plots, and these gave only one and two such plots each.

The aphis population had been increasing rapidly since early February, and when the plants were scored—on 2 and 3 April—many plots were completely defoliated.

Plots were scored for visual damage to foliage on a 0—5 scale, those with a score of 0 showing very little damage, and those with a score of 5 being completely defoliated.

Results

Mean scores and the range of scores for each variety are given below (Table I).

With a scoring system such as that used here, some sort of check on the objectiveness of scoring is necessary. The purpose of scoring must also be considered. A scoring system which delimits the resistant from the susceptible varieties is all that is required in the present instance. The grading of susceptible varieties according to their degree of susceptibility is not our present concern.

Because there are differences between replications, correlation of plot scores from different replications does not furnish conclusive evidence as to the consistency of scoring. Plots were therefore scored twice, without reference to code numbers, names, or to previous scores. Mean scores obtained on each occasion are given

TABLE I. MEAN SCORE AND RANGE OF SCORES IN RESISTANCE OF SWEDES TO APHIDS

No.	Variety	Mean Scores		Range	
		2/4/52	3/4/52	2/4/52	3/4/52
1	New Zealand Resistant	0.75	1.00	1	2
2	New Zealand Sensation Yellow fleshed	0.25	0.50	1	2
3	Webb's New Buffalo	2.00	2.50	1	1
4	Sharpe's A1	3.00	3.00	2	2
5	Sharpe's Ne Plus Ultra	2.50	2.25	1	1
6	Bangholm Otofte	2.75	3.00	1	2
7	Bangholm Wilby Otofte	1.25	0.75	1	2
8	Bangholm Pajberg	2.00	2.25	2	2
9	Bangholm Hinderupgaard	3.00	3.00	2	2
10	Granhovsdet Hunsballe	1.00	1.00	2	3
11	Sharpe's Paragon	2.75	2.50	3	2
12	Field's American Purple Top	2.75	2.50	1	1
13	Sharpe's Superlative	4.25	4.50	2	2
14	Sharpe's Vilmorin	1.00	0.75	0	1
15	Sharpe's Hernig	3.25	3.25	2	2
16	Wilhelmsburger Otofte	0.75	0.25	2	1
*17	Dunn's Defiance Purple Top	2.33	2.00	1	2
**18	Webb's Giant King	4.25	4.25	1	1
19	Lawson's Best of All	3.00	2.50	2	1
20	Sharpe's Paragon	3.25	3.25	1	1
21	New Zealand Sensation	0.25	0.25	1	1
22	Cullen's May Day	2.75	2.50	1	2
23	Cullen's Best of All	3.75	3.50	3	3
24	D.S. 32	3.00	3.00	2	2
25	Weibull's Queen	3.25	3.00	1	2
26	Weibull's Bangholm	3.50	3.00	1	2
27	Weibull's Ostgota I	2.25	2.25	2	1
28	Weibull's Bangholm	2.75	2.75	1	1
29	Weibull's Balder	1.00	1.00	2	2
30	Weibull's Balder II	1.50	1.75	3	3
31	Weibull's Wilhelmsburger	1.00	0.50	1	1
32	Weibull's Queen	2.75	2.75	1	1
33	Gota	3.00	2.75	3	2
34	Vilmorin's White Flesh Purple Top	0.25	0.50	1	1
35	Vilmorin's Perfect	2.25	2.25	3	3
36	Vilmorin's Champion Purple Top	3.25	3.00	2	2
37	Vilmorin's Yellow Flesh Green Top	2.50	2.25	3	3
38	Vilmorin's White Flesh Green Top	1.00	0.75	2	1
39	Aberdeen Prize Purple Top	3.75	3.50	3	4
40	Balmoral Purple Top	3.50	3.25	1	3
41	Balmoral Purple Top	3.75	3.50	2	2
42	Aberdeen Prize Purple Top	4.50	4.25	1	1
43	Calder	0.00	0.00	0	0
44	Grandmaster	2.50	2.50	1	1
45	Superlative	3.00	3.25	0	1

* 3 plots only ** 2 plots only

in Table I. Fifteen of the means are identical, 24 differ by 0.25 i.e. the total scores differed by one unit, and six differed by 0.50 (2 units). Of the 177 pairs of individual plot scores, 119 (67 per cent) were identical, 55 (31 per cent) differed by one unit, and only 3 (2 per cent) differed by two units. It is safe to conclude, therefore, that the plots were scored consistently and objectively.

There is also some other evidence that the variety means were obtained objectively. Six groups of varieties were represented by more than one line in the trial. These are: Wilhelmsburger Otofte (Varieties 1, 16, 31), Vilmorin white-flesh purple-top (14, 21, 34), Aberdeen (39, 40, 41, 42), Superlative (13,45), Bangholm (26,28), and Queen (25,32). Only one of these groups (Vilmorin) was readily identifiable, yet the mean scores within each group are reasonably close. From this evidence we can conclude that not only was the scoring objective, but also that the differences in mean scores are, to a large degree, genetically determined.

It is known that four of the lines tested (14, 21, 34, 43) have sufficient resistance to withstand heavy attacks of aphids in the field. The highest mean score of any of these is 1, so it is safe to rate as resistant varieties with a mean score of 1 or less. The varieties: New Zealand Yellow-fleshed Sensation, Wilhelmsburger Otofte, Bangholm Wilby Otofte, Granhovsdet, Hunsballe, Balder and Vilmorin's White-flesh green-top, can be added to the two known resistant varieties, Vilmorin white-flesh purple-top and Calder.

FIRST SUPPLEMENT TO "A REVISED LIST OF PLANT DISEASES RECORDED IN NEW ZEALAND" 1949-51.

By R. M. Brien and Joan M. Dingley, Plant Diseases Division, Department of Scientific and Industrial Research, Auckland

Introduction

(*Received for publication, 15 May 1952*)

In this supplement are listed 68 diseases of fungous, bacterial, and virus origin, on 98 host plants. It includes diseases and host plants recorded in publications since the preparation of "A Revised List of Plant Diseases Recorded in New Zealand" (Brien and Dingley, 1951) and additional host records. Fifteen of the diseases listed are recorded for the first time. No records of artificially infected host plants are included.

Two diseases (*Actinomyces scabies* and *Heliocobasidium purpureum*) recorded in early New Zealand literature, but not listed previously because of doubtful identification, have been included, since, during recent investigations, their identity has been established.

Abutilon sp. cult.
Nectria cinnabarina (Tode) Fr. .... Dingley, 1951

Agropyron scabrum (Labill.) Beauv.
Dilophospora alopecuri (Fr.) Fr. .... Additional host record

Alectryon excelsum Gaertn.
Verticillium dahliae Kleb. .... Smith, H. C., 1951

Anemone coronaria L.
Cucumber-mosaic virus—*Cucumis* virus 1 .... Cunningham, 1950

Antirrhinum majus L.
Phytophthora cactorum (Leb. & Cohn) Schroet. .... Additional host record

Apium australe Thouars
Septoria apii Chester .... Additional host record

Apium graveolens L.
Cucumber-mosaic virus—*Cucumis* virus 1 .... Cunningham, 1949

Brassica oleracea L. var. **acephala** DC.
Phoma lingam (Tode ex Fr.) Desm. .... Additional host record

Brassica rapa L.
Alternaria brassicae (Berk.) Sacc. .... New record

Cercosporella brassicae (Fautr. & Roum.) Hochnel .... New record

Glocosporium concentricum (Grev. ex Fr.) Berk. & Br. .... Additional host record

Callistephus chinensis Nees
Phytophthora cryptogea Pethybr. & Laff. .... Additional host record

Chamaecyparis lawsoniana Parlatore
Diplodia pinea (Desm.) Kickx .... Additional host record

Chenopodium album L.
Cercospora dubia (Riess) Wint. .... New record
Peronospora effusa (Grev. ex Desm.) Rabenh. Additional host record

Chrysanthemum morifolium Ramat.
Septoria chrysanthemella Sacc. .... New record

Cleome spinosa L.
Cystopus candidus (Pers. ex Chev.) Lev. ..... Additional host record

Coprosma australis (A. Rich.) Robins
Gibberella macrolopha (Syd.) Dingley ..... Dingley, 1952

Coprosma foetidissima Forst.
Gibberella macrolopha (Syd.) Dingley ..... Dingley, 1952

Coprosma robusta Raoul
Gibberella macrolopha (Syd.) Dingley ..... Dingley, 1952

Coprosma tenuifolia Cheesem.
Gibberella macrolopha (Syd.) Dingley ..... Additional host record

Cucumis sativus L.
Pythium ultimum Trow. .... Additional host record
Verticillium dahliae Kleb. .... Smith, H. C., 1951

Cucurbita pepo L.
Fusarium sp. .... New record

Cytisus proliferus L.
Gibberella baccata (Wallr.) Sacc. .... Dingley, 1952

Daphne odora Thunb.
Sclerotium rolfsii Sacc. .... Additional host record

Daucus carota L.
Helicobasidium purpureum Pat. .... Kirk, 1907

Delphinium cultorum Voss
Cucumber-mosaic virus—*Cucumis* virus 1 ..... Cunningham, 1949

Echinops sp.
Verticillium dahliae Kleb. .... Additional host record

Edwardsia microphylla (Ait.) Salisb.
Gibberella baccata (Wallr.) Sacc. .... Dingley, 1952

Erica sp.
Phytophthora sp. .... Cunningham, 1951

Festuca novae-zelandiae Armst.
Claviceps purpurea (Fr.) Tul. .... Additional host record

Ficus carica L.
Cercospora bolleana (Thuem.) Speg. ..... New record

Fragaria sp. cult.
Fusarium culmorum (W. G. Smith) Sacc. ..... Smith, H. C., in press
Pachybasium hamatum (Bon.) Sacc. var. *candidum* Sacc. .... Smith, H. C., in press
Pythium sp. .... Smith, H. C., in press
Verticillium dahliae Kleb. .... Smith, H. C., 1951

Gerbera jamesonii Bolus.
Verticillium dahliae Kleb. .... Smith, H. C., 1951

Gladiolus sp. cult.
Botrytis cinerea Pers. ex Fr. ..... Additional host record
Pleospora herbarum (Pers. ex Fr.) Rabenh. Additional host record
Cucumber-mosaic—*Cucumis* virus 1 ..... Cunningham, 1950
Pea-mosaic virus—*Pisum* virus 2 ..... Cunningham, 1951

Hoheria populnea A. Cunn.
Verticillium dahliae Kleb. ..... Smith, H. C., 1951

Ipomoea batatas Lam.
Diaporthe batatatis Harter & Field ..... New record

Iris sp.
Bacterium tardicrescens McCulloch ..... Cunningham, 1951

Iris tingitana Bois & Reut.
Mystrosporium adustum Mass. ..... Additional host record

Lathyrus odoratus L.
Tomato spotted-wilt virus—*Lycopersicum* virus 3 Cunningham, 1950

Lotus corniculatus L.
Ovularia exigua (W. G. Smith) Sacc. ..... New record

Luculia gratissima Sweet
Verticillium dahliae Kleb. ..... Smith, H. C., 1951

Lupinus angustifolius L.
Thielaviopsis basicola (Berk. & Br.) Ferraris Thomson, 1949

Lupinus arboreus L.
Gibberella baccata (Wallr.) Sacc. ..... Dingley, 1952

Lupinus luteus L.
Thielaviopsis basicola (Berk. & Br.) Ferraris Thomson, 1949

Lycopersicum esculentum Mill.
Glomerella cingulata (Stoneman.) Spauld & Schr. ..... Additional host record
Tobacco-mosaic virus—tomato aucuba-mosaic strain of *Nicotiana* virus 1 ..... Cunningham, 1949

Lychnis coeli-rosa Desr.
Tomato spotted-wilt virus—*Lycopersicum* virus 3 ..... Cunningham, 1949

Magnolia sp.
Phyllosticta magnoliae Sacc. ..... Canty. Agric. Coll., 1951

Matthiola incana R. Br.
Phytophthora cryptogea Pethybr. & Laff. ..... Additional host record
Septoria henriquesii Thuem. ..... New record

Medicago hispida Gaertn.
Pseudopeziza medicaginis (Lib.) Sacc. ..... Additional host record

Myoporum laetum Forst.
Septoria myopori Cke. & Mass. ..... Blair, 1951

Narcissus sp. cult.
Armillaria mellea (Fr.) Quel. ..... Additional host record

Nicotiana sanderae Sander
Verticillium dahliae Kleb. ..... Smith, H. C., 1951

Nothofagus sp.
Phytophthora sp. ..... Cunningham, 1951

Paeonia sp.
Glomerella cingulata (Stonemn.) Spauld & Schr. ..... Additional host record

Papaver nudicaule L.
Verticillium dahliae Kleb. ..... Smith, H. C., 1951

Paspalum distichum L.
Claviceps paspali Stevens & Hall ..... Additional host record

Petunia hybrida Vilm.
Phytophthora cryptogea Pethybr. & Laff. ..... Additional host record

Phaseolus vulgaris L.
Uromyces appendiculatus (Pers.) Link ..... New record

Phormium colensoi Hook. f.
Phormium yellow-leaf virus (not classified) Boyce *et al.*, 1951

Phormium tenax Forst.
Fusarium sp. ..... Cunningham, 1950
Gloeosporium sp. ..... Cunningham, 1950
Phormium yellow-leaf virus (not classified) Boyce *et al.*, 1951

Physalis peruviana L.
Tobacco-mosaic virus—tomato-streak strain of *Nicotiana* virus 1 ..... Cunningham, 1949
Tomato spotted-wilt virus—*Lycopersicum* virus 3 ..... Cunningham, 1949

Pinus radiata Don.
Phytophthora sp. ..... Cunningham, 1951

Plantago lanceolata L.
Diaporthe adunca (Rob. ex Desm.) Niessl ..... New record

Plantago major L.
Peronospora alta Fuckel ..... New record

Polygonum convolvulus L.
Peronospora polygoni Halsted ..... New record

Primula malacoides Franch
Ramularia primulae Thuem. ..... Additional host record
Tomato spotted-wilt virus—*Lycopersicum* virus 3 ..... Cunningham, 1949

Prunus armeniaca L.
Plum-mosaic virus (not classified) ..... Chamberlain *et al.*, 1951

Prunus cerasifera Ehrh.
Plum-mosaic virus (not classified) ..... Chamberlain *et al.*, 1951

Prunus communis Fritsch
Verticillium dahliae Kleb. ..... Additional host record

Prunus domestica L.
Plum-mosaic virus (not classified) ..... Chamberlain *et al.*, 1951

Prunus insititia L.
Plum-mosaic virus (not classified) ..... Chamberlain *et al.*, 1951

Prunus lusitanica L.
Stereum purpureum (Pers. ex. Fr.) Fr ..... Additional host record

Prunus mahaleb L.
Plum-mosaic virus (not classified) ..... Chamberlain *et al.*, 1951

Prunus persica Sieb. & Zucc.
Verticillium dahliae Kleb. ..... Smith, H. C., 1951
Plum-mosaic virus (not classified) ..... Chamberlain *et al.*, 1951

Prunus salicina Lindl.	
Plum-mosaic virus (not classified)	Chamberlain *et al.*, 1951
Pyrus communis L.	
Gibberella baccata (Wallr.) Sacc.	Dingley, 1952
Phytophthora cactorum (Leb. & Cohn) Schroet.	Additional host record
Pyrus malus L.	
Phytophthora cactorum (Leb. & Cohn) Schroet.	Smith, H. C., 1950
Ranunculus sceleratus L.	
Tomato spotted-wilt virus—*Lycopersicum* virus 3	Cunningham, 1949
Raphanus sativus L.	
Tomato spotted-wilt virus—*Lycopersicum* virus 3	Cunningham, 1949
Rhaphiolepis indica Lindl.	
Fabraea maculata Atk.	Additional host record
Rheum rhaponticum L.	
Phyllosticta rheina (Thuem. & Boll.) Allesch.	New record
Rhus cotinus L.	
Verticillium dahliae Kleb.	Additional host record
Ribes grossularia L.	
Phytophthora cactorum (Leb. & Cohn) Schroet.	Smith, H. C., 1950
Ribes sanguineum Pursh.	
Nectria cinnabarina (Tode) Fr.	Dingley, 1951
Robinia pseudoacacia L.	
Gibberella baccata (Wallr.) Sacc.	Dingley, 1952
Rosa eglanteria L.	
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Rosa sp. cult.	
Leptosphaeria coniothyrium (Fuckel) Sacc.	Additional host record
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Rubus sp. (Boysenberry)	
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